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NOTICE.

ANNUAL CONVENTION.

The annual convention of the New England Water Works Association will be held in Burlington, Vt., on the 11th, 12th and 13th of September, 1895.

The programme, to be announced later, consists of papers of the usual interest, carriage rides in Burlington and vicinity and a sail on Lake Champlain with a visit to Ausable Chasm.

More than the usual effort will be made to entertain the ladies and a large attendance is expected.

Ample provision will be made for the exhibit of Water Works supplies.

J. C. WHITNEY, SECRETARY,

West Newton, Mass.

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NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. IX. June, 1895. No. 4.

This Association, as a Body, is not responsible for the statements or opinions of any of its members.

ADJOURNED MEETING.

YOUNG'S HOTEL, BOSTON, MASS., February 13, 1895.

The following members and guests were present:

MEMBERS.

E. L. Abbott, Boston, Mass.; Charles H. Baldwin, Boston, Mass.; Lewis M. Bancroft, Reading, Mass.; George E. Batchelder, Worcester, Mass.; Joseph E. Beals, Middleboro, Mass.; George Bowers, Lowell, Mass.; Dexter Brackett, Boston, Mass.; Arthur W. F. Brown, Fitchburg, Mass.; George F. Chace, Taunton, Mass.; E. J. Chadbourne, Wakefield, Mass.; John C. Chase, Wilmington, N. C.; William F. Codd, Nantucket, Mass.; F. C. Coffin, Boston, Mass.; R. C. P. Coggeshall, New Bedford, Mass.; George K. Crandall, New London, Conn.; George E. Evans, Boston, Mass.; Desmond FitzGerald, Brookline, Mass.; F. F. Forbes, Brookline, Mass.; Z. R. Forbes, Brookline, Mass.; F. L. Fuller, Boston, Mass.; L. L. Gerry, Stoneham, Mass.; Albert S. Glover, Boston, Mass.; Frank E. Hall, Quincy, Mass.; George W. Harrington, Wakefield, Mass.; John L. Harrington, Cambridge, Mass.; William E. Hawks, Bennington, Vt.; Allen Hazen, Boston, Mass.; H. G. Holden, Nashua, N. H.; H. N. Hyde, Newtonville, Mass.; George A. Kimball, Boston, Mass.; J. W. Locke, Brockton, Mass.; William J. Luther, Attleboro, Mass.; William McNally, Marlboro, Mass.; Thomas Naylor, Maynard, Mass.; Albert F. Noyes, Boston, Mass.; John H. Perkins, Watertown, Mass.; Edward H. Phipps, New Haven, Conn.; Dwight

Porter, Boston, Mass.; George S. Rice, Boston, Mass.; H. E. Royce, Brookline, Mass.; W. H. Richards, New London, Conn.; George J. Ries, Weymouth Centre, Mass.; Daniel Russell, Everett, Mass.; Caleb M. Saville, Malden, Mass.; F. J. Shepard, Derry, N. H.; H. O. Smith, Leicester, Mass.; George A. Stacy, Marlborough, Mass.; Edwin A. Taylor, Boston, Mass.; Lucian A. Taylor, Boston, Mass.; Robert J. Thomas, Lowell, Mass.; William H. Thomas, Hingham, Mass.; M. M. Tidd, Boston, Mass.; D. N. Tower, Cohasset, Mass.; W. H. Vaughn, Wellesley Hills, Mass.; George C. Whipple, Brighton, Mass.; Horace B. Winship, Norwich, Conn.; George E. Winslow, Waltham, Mass.; E. T. Wiswall, West Newton, Mass.; Henry B. Wood, Boston, Mass.; E. Worthington, Jr., Boston, Mass.; James M. Betton, Boston, Mass.; A. H. Broderick, Chadwick Lead Works, Boston, Mass.; E. L. Ross, Chapman Valve Manufacturing Co., Indian Orchard, Mass.; Z. E. Coffin, Coffin Valve Co., Boston, Mass.; F. H. Hayes, Deane Steam Pump Co., Holyoke, Mass.; Charles H. Eglee, Flushing, N. Y.; N. N. Libbey, Gilchrist & Taylor, Boston, Mass.; S. Harrison, Hersey Manufacturing Co., South Boston, Mass.; W. W. Wilson, Holyoke Hydrant and Iron Works, Holyoke, Mass.; Henry F. Jenks, Pawtucket, R. I.; Wilmer Reed, McNeal Pipe and Foundry Co., Burlington, N. J.; B. G. Russell, Secretary Peet Valve Co., Boston, Mass.; H. L. Bond, Perrin, Seamans & Co., Boston, Mass.; H. H. Kinsey, Rensselaer Manufacturing Co., Troy, N. Y.; W. H. Van Winkle, A. P. Smith, Newark, N. J.; Franklin A. Snow, Providence, R. I.; H. B. Temby, Boston, Mass.; J. R. K. Otis, Union Water Meter Co., Worcester, Mass., Jesse Garrett, R. D. Wood & Co., Philadelphia, Pa.

GUESTS.

J. A. Beech, Taunton, Mass.; M. F. Brennan, Lowell, Mass.; J. E. Bunting, Cambridge, Mass.; E. W. Bush, Waterbury, Conn.; Henry A. Cutter, Nashua, N. H.; F. G. Perry, Pawtucket, R. I.; M. J. Doyle, Lowell, Mass.; A. A. Forbes, Pittsfield, Mass.; George Goodline, Concord, N. H.; Weston Lewis, Gardner, Me.; F. H. Parker, Burlington, Vt.; George E. Putnam, Lowell, Mass.; A. H. Sweet, Norton, Mass.; S. H. Taylor, New Bedford, Mass.

The following applications for resident active membership were received: A. G. Bancroft, Civil Engineer, Reading, Mass.; F. G. Perry, Assistant Commissioner Public Works, Pawtucket, R. I.; F. L. Taylor, Engineer Brookline Water Works, Brookline, Mass.; S. G. Armstrong, Civil Engineer, Cambridge, Mass.; Edward W. Bush, Civil Engineer, Waterbury, Conn.; A. A. Forbes, Engineer Board of Public Works, Pittsfield, Mass.; R. A. Cairns, City Engineer, Waterbury, Conn.; J. Albert Welch, Meter Inspector, Taunton, Mass.

On motion of Mr. Coggeshall, it was voted that the Secretary be instructed to cast one ballot for the candidates, and the Secretary having performed this duty, reported that the candidates named were elected.

Mr. Brackett, Secretary pro tem, reported that the committee appointed at the last meeting to consider the question of the election of a Secretary for the balance of the year had nominated for that office Mr. J. C. Whitney of Newton.

The report was accepted and the Secretary was instructed by unanimous vote of the Association to cast a ballot for J. C. Whitney as Secretary of the Association for the unexpired term.

The Secretary pro tem performed the duty assigned and announced the fact that Mr. J. C. Whitney had been elected Secretary of the Association for the balance of the year.

Mr. G. C. Whipple, of the Boston Water Works, read a paper upon "Some Observations on the Temperature of Surface Waters and the Effect of Temperature on the Growth of Micro-Organisms."

The paper was discussed by Messrs. FitzGerald, Forbes, Winslow, Porter, Chace and Stacy.

Mr. A. W. F. Brown, of Fitchburg, read a paper describing a "Card System of Service Pipe Locations," which was discussed by Mr. Chase.

Mr. Beals, of Middleboro, exhibited and described the advantages of a ladle which he had used for carrying lead.

Mr. Coggeshall presented, as a topic for discussion, the following letter which he had received from the Department of Public Works in Providence:

"DEPARTMENT OF PUBLIC WORKS,
COMMISSIONER'S OFFICE, CITY HALL,
PROVIDENCE, R. I., January 3, 1895.

Superintendent of Water Works, New Bedford, Mass.

DEAR SIR: Recent requirements of insurance companies in the matter of private fire supplies call for a careful consideration of the important question of permitting, in accordance with their rules, the connection to private fire supplies of steam pumps that are not supplied with city water but are supplied from some source, contaminated or otherwise, independent of the city water mains. Dependence is placed upon the uncertain action of a check valve to prevent the dangerous pollution of the water in the city mains.

Another matter of not so much importance is the plan of running private fire supplies through private buildings, frequently without the knowledge or consent of the water department, and connecting one district of water mains with another district. This increases the liabilities of the city on account of damages occasioned by delay in closing a district of water mains when a break has occurred in one of the mains.

As it is a subject in which all water departments are mutually interested, we inclose a list of questions answered in accordance with the rules and regulations of this department governing the matter, and also a duplicate list which if you will kindly answer, the information will be greatly appreciated."

The circular is signed by Robert E. Smith, commissioner of public works.

Then the questions were:

"1. Are private fire supplies permitted, and under what restrictions?

A. Yes. On condition that water shall be used for no purpose other than fires.

2. What rate, if any, is charged?

A. No charge.

3. Is more than one private fire connection from the street main permitted to a building?

A. Two supplies are allowed.

4. When a building fronts on two or more streets is it allowable to run a private fire connection from each street and connect them together so as to afford circulation through the building from one street to another?

A. Yes, but only two connections allowed.

5. In order to increase the pressure on a private fire supply is it allowable to connect a steam pump not supplied with city water but with water taken from a tank, cistern, or some source other than the city water mains, but so arranged that one or both kinds of water may be sent through the pipes?

A. Not allowed, unless the steam pump is connected with city water and none other.

6. If allowable, what device is required to prevent such water from being forced into the distribution mains and polluting the water in the mains?

A. The insurance companies use check valves, but this department claims that where the supply for steam pumps is polluted the check-valve is not sufficient to prevent the water in the mains being defiled.

7. Have you observed any violations of rules governing private fire supplies, such as the use of water from same for general purposes without permission, especially when meters are set to register water used for general purposes?

A. Use of water from private fire supplies without permission has been quite frequent and to prevent same all outlets from private fire supplies have been sealed and are occasionally inspected."

Mr. Coggeshall. In the city which I represent there are a number of very large mills. Each is provided with one or more large supply pipes which maintain a constant pressure upon the sprinklers and hydrants. A check valve is placed in this supply pipe opening inward just beyond the controlling gate where it leaves the city main. Then by means of a steam pump placed near the engine room of the mill salt water may be forced against this check valve and thus the pressure upon both sprinkler and hydrants may be raised say 30 pounds above the normal city pressure.

At a mill fire a few years since the sprinklers worked all right and the steam pumps of the mill were soon started up. It was assumed of course that the check valve would close and that the supply to sprinklers would be wholly cared for by the mill pump. But here was a case where the check failed to operate.

Soon after the arrival of the fire department one of the fire engineers said to me: "Let us go into the office and get a drink of water." He turned on a faucet and it was amusing to see him turn himself inside out when he went to drink the water. Just about that time word came down that all the steamers were thrown out of commission on account of trouble with salt water which had been forced into the city mains. I immediately sized up the situation and

went down and stopped the steam pump. The fire did not amount to much, but if it had, of course every steamer there would have been thrown out of service as the salt water had caused foaming in the boilers of the steamers. The question is, what is to be done in such a case? It seems as though a check valve cannot be altogether depended upon. I would like to hear the expression of others on this point. Since that fire we have carefully examined every check valve connected with our distributing system, and we found three in a condition where they would not operate in case of a supply being forced from the steam pump. I presume the reason is because the water is always going one way, and it is very seldom that they operate the pumps against the check valve. The valves were found opened as widely as possible and such a large amount of vegetable deposit had collected and hardened that it was impossible for the valve to change its position in the least. It was necessary to remove all the sediment thus collected before the valve could be operated in the least.

MR. TIDD. I would like to ask the gentleman how a check valve could stand that way without the engineer knowing it.

MR. COGGESHALL. In the case just stated it seems that the engineer did know that something was wrong, because he had attempted to raise the pressure and was unable to do so, but he refrained from saying anything about it until we discovered the trouble. The mill people are supposed to make frequent trials of their facilities, but in the case just reported it was simply impossible for them to obtain heir fire pressure, for the checks were stuck fast wide open and they were engaged in pumping undesirable water into the city mains.

MR. TIDD. Well, it shows conclusively that no attention whatever was paid to the condition of the valves, and it seems to me the insurance people were pretty lax in the matter.

MR. COGGESHALL. That is the point.

MR. CHASE. I am inclined to think that there is no better or more efficient way of arranging a fire supply than by having check valves, using a reasonable amount of attention to assure that they are kept in order. I have had some experience with the arrangement that Mr. Coggeshall speaks of, and have had no trouble whatever. For example, we have on our main that supplies the standpipe, a check valve constructed according to a device that I approve. The valve portion instead of swinging on the pin of the valve is fastened to it. The hinge pin is extended through a stuffing box in the side of the valve and has a lever attached to it, somewhat similar to the construction of the Goldsmith Steam Valve. The valve is ordinarily held open by a wire cord running some 200 feet to the pumping station, and the water flows in and out of the standpipe freely. When an alarm of fire comes and it is desired to shut off the standpipe to raise the pressure, the engineer steps to the hook, and drops the check valve. This has been used for eight years, probably sixty times during every year, and it hasn't stuck once during that time. I think that all owners of buildings depending on water works for fire protection, should have a supply from two streets, if it can be obtained. Then they are sure of a supply if the supply in one street is shut off. In these cases two check valves are put in, opening in-

ward, one from each street. We have had no complaint of water passing through. The check valves of our pumps have never given any trouble. I think that any of the superintendents here who do steam pumping will find that the check valve is kept in order as easily as any part of the pumping machinery, and I think that any difficulty found with check valves can be easily remedied.

MR. COGGESHALL. I don't see any reason why a check valve under the conditions Mr. Chase refers to should not work, as it is used a number of times during each year. The check valves connected with our pumping station give no trouble. But what I refer to is one of these independent mill supplies, where there is a check valve on one line of pipe that is only used in one way perhaps for a year or two years before it is ever tried in the other direction.

MR. CHASE. A word further. I cannot see how a check valve could be on any line of pipe that is used at all without being in action. The normal condition of a check valve is closed. As soon as any water is drawn it begins to open slightly. Now, if there is any defect in it so that it is held wide open in some way, of course it will not shut when the pressure is reversed. But if it shuts at all I should think it would open and shut with the utmost freedom, no matter when the pressure was reversed. In fact, in all these cases the pressure is reversed when the flow of water ceases; the static pressure inside closes the valve. I think check valves are usually as reliable as any other piece of mechanism.

MR. COGGESHALL. I would say that all that argument seems perfectly logical and perfectly correct. Nevertheless, I have found this year three check valves wide open, just as if they were fastened.

MR. TIDD. There is no simpler mechanism than a check valve. It is the most simple device that can be imagined for opening and shutting in a direct line. It must open when water passes through it and when it stops it must close. I would as soon think of finding a pump without a cylinder as a check valve that wouldn't work. It shows gross negligence on someone's part. Certainly there is no inherent defect in the principle of the check valve.

MR. COGGESHALL. There is one corporation in New Bedford that has eight 6-inch connections, two 8-inch connections, and somewhere from a dozen to fifteen check valves in different parts of the system.

MR. TIDD. I would like to ask Mr. Coggeshall who made those check valves, and whether they were made of iron or composition in the wearing parts?

MR. COGGESHALL. Composition. I wouldn't like to tell the name. They are recognized as being as good as any make.

MR. TIDD. I use a great many check valves. I have been using them for thirty years, both large and small ones, and never had any trouble with them.

MR. COGGESHALL. I never would have any trouble with them if they were in connection with the system itself, and on the mains, of which we have the care. It is simply because they are supposed to be cared for by the mill people and inside of their property that this thing happens, and for our own protection we are now overhauling them ourselves.

MR. TIDD. I had the impression that the insurance people were sensitive on that point and looked after those things pretty sharp. Somebody has been lax in duty.

MR. BROWN. Speaking for Fitchburg, we have numerous check valves, all iron except the linings. There is a check valve on each service. Many of them that we haven't seen for a good while. We suppose they work all right, as we have no trouble when water is shut off.

MR. COGGESHALL. This question came up in the city of Providence. The city of Providence do not allow a connection in any mill or anywhere else where there is a supply other than the city water to come back upon it by a check valve. The insurance companies, I guess, have been stirring them up, and that is the reason they have issued this circular at this time. I would state to Mr. Brown the manner in which I found out and located two check valves that didn't work. There were two mills in our city located side by side, but taking their supplies from different streets. The two supplies are connected that the fire pumps may operate on the systems of both mills. Two check valves, opening inward from each street was provided. It was noticed that the meter of one mill registered an unusual amount, while the other gradually diminished, until finally it commenced to run backwards. Then suspicion for the cause of the trouble pointed to the check valve and both checks were found wide open and in a manner where it was simply impossible for the valve to change its position.

MR. CHASE. They must use a tremendous amount of water there if it is hung up all the time. That may account for where some of the waste goes to.

MR. BROWN. Would it not make a difference in Mr. Coggeshall's case, there being a salt water supply for pumps, instead of the fresh water that most of us have? That might account for the valve being hung up.

MR. BRACKETT.—I think the use of salt water may perhaps be the reason why he discovered that the valves were out of order, when others of us might not.

MR. COGGESHALL.—That is just exactly the point, and that is the reason I brought the question to your attention.

Mr. William H. Thomas presented a paper written by the late Chas. W. S. Seymour* enlitled "An Experience with Anchor Ice and a Pressure Gauge."

THE LEGALITY OF SUPPLYING WATER IN ADJOINING TOWNS.

MR. BRACKETT.—A modest member has handed me a question to propound. A man owns several tenements occupied by stores, families and boarding houses, on a lot through which the town line passes, part of the premises supplied being in each of the two towns. He now uses water from one town on the whole premises. Has he a right to do so? He applies for water from the other town to supply the whole premises, shutting off the first supply. Has the second town a right to grant his request? Has the owner the right to use water from either town on his premises in the other town?

*See Vol. VIII, page 108.

THE PRESIDENT.—Can any member answer these questions?

MR. FULLER.—Mr. President. At Methuen we have a case somewhat similar to this. The Arlington Mills are situated partly in the city of Lawrence and partly in the town of Methuen, and the pressure given by the Methuen works is considerably greater and the water probably somewhat better. They desired to take water from the Methuen works and the pipes were laid, and I suppose that they have carried their own pipes through their own property to the adjoining city of Lawrence. This same question has arisen as to the legality of the town of Methuen supplying water which will go to the city of Lawrence, but I do not know how the question has been settled. Mr. Mann, one of the water commissioners is here, and perhaps he can tell us what the condition of things is at present. I suppose where a charter is granted to supply a town and its inhabitants with water, that the water is expected to go no farther. Of course the point comes up that these people pay for the water and take it. For instance, in this case in the town of Methuen, they have a right to use it on their own premises. But I think it is rather a perplexing question, and I don't know how it could be settled legally. The Lawrence people object to Methuen's furnishing all the water that the Arlington Mills use.

MR. MANN.—Mr. President. I don't know that I can give you any light on how the matter was settled. Mr. Fuller has spoken about the case of the Arlington Mills. I know that the town of Methuen has not put any pipes in Lawrence, and the mills propose to run water in through their pipes. If the Arlington Mills go into Methuen and take water from their own ground, it is a question for a bigger head than mine to solve whether they have a right to use water on their own ground. That is a question that I, for one, should like to see answered.

Adjourned at 4:15 p. m., on motion of Mr. Coggeshall.

QUARTERLY MEETING.

YOUNG'S HOTEL, BOSTON, MASS., March 13, 1895.

The following members and guests were present:

MEMBERS.

Everett L. Abbott, Boston, Mass.; Chas. H. Baldwin, Boston, Mass.; Geo. E. Batchelder, Worcester, Mass.; Jas. E. Beals, Middleboro, Mass.; Dexter Brackett, Boston, Mass.; A. W. F. Brown, Fitchburg, Mass.; Edward W. Bush, Waterbury, Conn.; Geo. F. Chace, Taunton, Mass.; Chas. E. Chandler, Norwich, Conn.; John C. Chase, Wilmington, N. C.; Harry W. Clark, Lawrence, Mass.; Freeman C. Coffin, Boston, Mass.; R. C. P. Coggeshall, New Bedford,

Mass.; Byron I. Cook, Woonsocket, R. I.; F. H. Crandall, Burlington, Vt.; Geo. K. Crandall, New London, Ct.; John W. Ellis, Woonsocket, R. I.: B. R. Felton, Marlboro, Mass.; F. F. Forbes, Brookline, Mass.; Frank L. Fuller, Boston, Mass.; X. H. Goodnough, Boston, Mass.: F. W. Gow, Medford, Mass.; Wm. R. Grace, Rockland, Mass.; E. A. W. Hammatt, Boston, Mass.; John C. Haskell, Lynn, Mass.; Frank E. Hall, Quincy, Mass.; V. C. Hastings, Concord, N. H.; T. G. Hazard, Jr., Narragansett Pier, R. I.; Allen Hazen, Boston, Mass.; Horace G. Holden, Nashua, N. H.; Willard Kent, Woonsocket, R. I.; Jas. W. Locke, Brockton, Mass.; Wm. J. Luther, Attleboro, Mass.; Chas. W. Mann, Methuen, Mass.; Wm. McNally, Marlboro, Mass.; Albert F. Noyes, Boston, Mass.; F. G. Perry, Pawtucket, R. I.; Dwight Porter, Boston, Mass.; Walter H. Richards, New London, Conn.; Geo. J. Ries, Weymouth Centre, Mass.; A. H. Salisbury, Lawrence, Mass.; Caleb M. Saville, Malden, Mass.; H. O. Smith, Leicester, Mass.; J. Waldo Smith, Montclair, N. J.; Geo. A. Stacy, Marlborough, Mass.; Jas. H. Stanwood, Boston, Mass.; F. P. Stearns, Boston, Mass.; F. L. Taylor, Brookline, Mass.; Lucian A. Taylor, Boston, Mass.; M. M. Tidd, Boston, Mass.; W. H. Vaughn, Wellesley Hills, Mass.; Chas. K. Walker, Manchester, N. H.; J. A. Welch, Taunton, Mass.; John C. Whitney, West Newton, Mass.; Horace B. Winship, Norwich, Conn.: Geo. E. Winslow, Waltham, Mass.; E. Worthington, Jr., Boston, Mass.; Jas. M. Betton, Boston, Mass.; A. H. Broderick, Chadwick Lead Works, Boston, Mass; E. L. Ross, Chapman Valve Mfg. Co., Indian Orchard, Mass.; F. H. Hayes, Dean Steam Pump Co., Holyoke, Mass.; S. Harrison and J. A. Spofford, Hersey Mfg. Co., So. Boston, Mass; Wm. D'. H. Washington, the Hydraulic Construction Co., New York city; Henry F. Jenks, Pawtucket, R. I.; B. G. Russell and S. B. Adams, Peet Valve Co., Boston, Mass; H. L. Bond, Perrin, Seamans & Co., Boston, Mass.; Franklin A. Snow, Providence, R. I.; H. B. Temby, Boston, Mass.

The Secretary read the names of applicants for membership as follows:

RESIDENT ACTIVE.

Henry G. Hunter, C. E., Boston; H. H. Nash, C. E., Boston; Charles W. Richardson, water commissioner, Everett.

NON-RESIDENT ACTIVE.

Mackey J. Thompson, LaCrosse, Wis., Resident Engineer Wigwam Dam, Thomaston, Conn.

On motion of Mr. Coggeshall the Secretary was directed to cast the ballot of the Association for the gentlemen whose names he had read, and he having done so, they were declared elected members of the Association.

GUESTS.

John C. D. Melto, Jr., New Bedford, Mass.; Geo. E. Fellows, Mackey J. Thompson, Waterbury, Conn.: S. H. Taylor, New Bedford, Mass.; D. W. Tenney, Methuen, Mass.

CHANGE OF DATE OF ANNUAL CONVENTION.

THE PRESIDENT. Gentlemen, you voted at your last annual meeting to hold the next annual convention in Burlington, Vermont. The constitution provides that our annual meeting shall be held on the second Wednesday in June, which, I think, this year will be on the 12th. We were informed by Mr. Crandall that the principal hotel in Burlington was engaged for that week by the Knights Templars of the State, and while we have never found a hotel which was any too large for us, we have often found our accommodations rather cramped. The hotel was not engaged for the following week, but the week after that, another convention is to meet in Burlington and at that hotel.

Your committee visited Burlington and after looking the place over, came to the conclusion that the hotel for the headquarters of the Association was the one engaged by Knights Templars. It is very pleasantly situated, the rooms are all good, and most of them have a view of the lake and the Adirondack Mountains across the water. We therefore decided that it would be best to change the date of the convention, and hold the meeting there the week after the Knights Templars convention, that is on the 19th, 20th and 21st. We made arrangements at the hotel for the Secretary's room and the exhibit of the associate members, everything being very favorably situated. The meetings of the convention will be held in the City Hall, which is just across the park from the hotel. The impression we received of Burlington was that it will be a very desirable place to visit, and that any member will be amply repaid and refreshed by his visit there.

Last evening, at the annual dinner of the Boston Society of Civil Engineers, the President of the American Society announced that their annual convention was to be held in Boston this year, beginning on the 18th of June. It is evident that this convention would effect our meeting at Burlington, if held at the same time, as a large number of the active members of this Association, who have assisted in making our meetings pleasant and interesting, are members of the Boston Society of Civil Engineers, and as it is a duty encumbent upon them to return the courtesies which they have received in other places.

It is also probable that outside of the members who belong to the Boston Society there are many members of the New England Water Works Association who would be glad to embrace the opportunity to attend some part of the convention of the American Society. If this convention was held in New England every year I should look at it differently. But this is a National Association, and they have not held a meeting here for 17 years, and we could not consistently ask them to change their date, when we had already changed ours to a different time than is called for by our constitution.

We also learned that the American Water Works Association will meet the last of May, and that the summer hotels and other places of resort in the vicinity of Burlington might not be open before the middle of June, so we seemed to be driven into a corner. After carefully considering the question we have concluded that it will be for the best interest of the Association to change the time of holding the convention from June to September. We intend to hold our

annual meeting when the constitution provides, on the 12th day of June, and to adjourn that meeting to the second week of September at Burlington.

This, I may say, is a final decision, and I make this explanation, so that you may know the reasons why we give way in this matter. It is in some respects a selfish reason, but it is made to accommodate those who belong to both associations.

You will be notified of the arrangements as soon as they are made, and I hope we shall go to Burlington in large numbers, and have an enthusiastic meeting. I know everything will be done there to make our visit pleasant.

Mr. Crandall has worked hard from the start, and I feel worse on his account because of this postponement than for almost anything else. I know it is embarrassing, after having arranged to go in June, and after we had declined a previous invitation, to postpone going there now, and perhaps, not knowing all the circumstances, the people of Burlington may not appreciate the present situation. But we shall go there just the same, and I think the first or second week in September, whichever it may be, will be a very pleasant time to visit that city. And I also know, both from my own observation and from what others have told me, that there is no place in New England where we can go and enjoy ourselves any better than we can there. It is intended to make the trip pleasant for the ladies who attend the convention. At some of our meetings we have not had the opportunity to entertain the ladies during the sessions of the convention, in which, perhaps, they cannot be expected to take much interest; but it is proposed to take care of them every day at Burlington, and I think the program will be carried out. While we are attending to our business the ladies can play.

This is the program as arranged at the present time, and these are the reasons why we propose to make the change—out of courtesy to the members of the Boston Society of Civil Engineers who belong to us, and for the interest, primarily, of our Association.

Committee to Nominate Officers.

On motion of Mr. Coggeshall it was voted that the President be authorized to appoint a committee, consisting of five members, to report at the annual convention in June, or at the adjourned meeting in September, a list of officers for the consideration of the Association.

The President announced he would take time to appoint the committee.

Papers were presented by F. L. Fuller on "The Water Supply of Webster," J. C. Haskell on "How to Reduce the Excessive Consumption in Our Cities and Towns," L. A. Taylor on "The Use of Tapping Bands on Cast Iron Pipe," and G. E. Winslow on "The Use of Air in Pressure Gauges."

Adjourned.

SOME OBSERVATIONS ON THE TEMPERATURE OF SURFACE WATERS; AND THE EFFECT OF TEMPERATURE ON THE GROWTH OF MICRO-ORGANISMS.

BY

GEORGE C. WHIPPLE, BIOLOGIST, Boston, Mass.

[Read Feb. 13, 1895.]

From a scientific, as well as from a practical standpoint, the study of the temperature of surface waters is interesting and important. It is interesting to the scientist because the temperature changes which occur in a body of water are sufficient to account for numerous physical phenomena, and it is important to the water works engineer for reasons that are well known and which will be recalled by merely mentioning the words "anchor ice" and "frozen water pipes." It is known also that the temperature of the water at the surface of a pond has an important effect on evaporation.

In this paper I shall endeavor to show that temperature has an influence upon the quality of the water stored in a reservoir, in that it directly or indirectly affects the growth of the micro-organisms therein.

When the biological laboratory of the Boston Water Works was established by Mr. Desmond FitzGerald in 1889 it was decided to record the temperature of every sample of water collected; and, as these samples have been taken with great regularity, we now have a series of weekly temperature observations covering a period of five years. Furthermore, numerous special sets of temperature observations have been made during portions of each year to throw light upon certain important questions.

TEMPERATURE STATIONS.

The regular weekly observations were made at the following places:
Lake Cochituate, at the surface, mid-depth, and bottom, (60 feet.)
Basin 2, at the surface, mid-depth, and bottom, (20 feet.)
Basin 3, at the surface, mid-depth, and bottom, (25 feet.)
Basin 4, at the surface, mid-depth, and bottom, (45 feet.)
Chestnut Hill Reservoir, at the surface, mid-depth, and bottom, (28 feet.)
Chestnut Hill Reservoir, in the gate-houses.
Brookline Reservoir, in the gate-house.
Service tap in Park Square, Boston.
Service tap in Mattapan.
In the brooks entering the storage basins, etc.

In Lake Cochituate and in Basin 4 observations were taken at intervals of five feet from the surface to the bottom, during the summer months. Ordi-

narily the observations were taken in the forenoon between the hours of eight and ten.

Thermometers.

The thermometers used were nine inches long, graduated on the stem to half degrees from 0° to 120° F.

This range was longer than was necessary, but was the best obtainable without special manufacture. For protection they were mounted in wooden cases, which were weighted in order that they might be used under water.

Readings at points below the surface were obtained by lowering a thermometer in a gallon bottle enclosed in a metal frame, to which the sinking cord was attached. A cork having a separate cord was placed in the mouth of the bottle and allowed to remain during the descent. When the bottle had reached the proper depth the cork was pulled, whereupon the bottle immediately filled with water. After allowing it to remain about ten minutes in order to acquire the temperature of the surrounding water, the bottle was rapidly drawn to the surface and the reading taken.

In this method it was necessary to guard against several sources of error, among which may be mentioned the following:

1. Error from not leaving the bottle down long enough to acquire the temperature of the surrounding water. To avoid this error, in finding the temperature of the water at the bottom of Lake Cochituate, a thermometer was kept at the bottom throughout the summer, being drawn to the surface only when readings were to be taken.

2. Error from change of reading while the bottle was being drawn to the surface. In warm weather when the surface and bottom temperatures sometimes differ by more than 30° F., this becomes of some importance, though ordinarily it is less than 0.2°.

3. Error from change of temperature after the bottle has been draw up and before the reading is taken. This error is usually negligible if the bottle is not placed in the sun and if the reading is made promptly.

4. Error from not holding the thermometer at right angles to the line of sight. This is the greatest source of error, and may easily amount to half a degree.

5. Error from refraction, caused by not holding the thermometer parallel to the sides of the bottle.

Thermophone.

On some of our more recent work we have used an electrical device invented by Mr. Henry E. Warren, of Newton Centre, and the writer of this paper. To this instrument we have given the name "Thermophone," because the temperature readings are obtained by listening to the sound made in a telephone.

Briefly described, the thermophone is an arrangement of resistances in the form of a Wheatstone's Bridge. Coils of resistance wires, enclosed in a brass tube, are located at the place where the temperature is desired. These coils are connected by leading wires to the indicating portion of the apparatus, where the movement of a contact along a "Slide Wire" is effected by turning a knob, which, at the same time, moves a pointer over a dial graduated in

degrees of temperature. In place of the galvanometer, usually used with a Wheatstone's Bridge, a telephone with an interrupter in its circuit is used to indicate the presence of a current. The absence of sound in the telephone indicates that the bridge is balanced. Readings are taken with the thermophone by holding the telephone to the ear while the pointer is moved over the dial by means of the knob. When there is silence in the telephone the pointer will indicate the correct reading.

With this instrument we have been able to obtain readings to 0.05° F., and it sets so rapidly that not more than a minute is required to make an observation.

Results of Observations.

Some of the results of the observations from January 1, 1890, to January 1, 1895, are shown on Plates 1 and 2.

Plate 1 shows the temperatures at the surface and bottom af Lake Cochituate, Chestnut Hill Reservoir, and Basins 2, 3 and 4. The surface temperatures, being practically the same in the different reservoirs, have been plotted as one

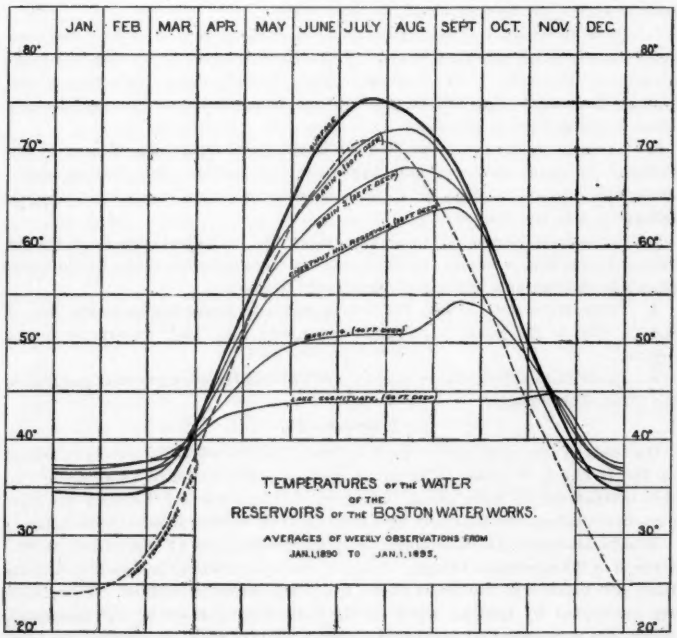


Plate 1.

line. It will be noticed that the temperature of the water at the bottom of the reservoirs depends upon the depth. In Basin 2, which is about 20 feet deep, the temperatures at the surface and bottom are almost the same. Basin 3 is 25 feet deep, and the bottom temperature during the summer is much lower than in Basin 2. During a portion of the summer the lower layers are quite stagnant, that is to say, there is no vertical circulation. In Chestnut Hill Reservoir, 28 feet deep, and in Basin 4, 45 feet deep, the summer temperatures at the bottom are still lower. The rise of the temperature at Basin 4 during September is occasioned by the drawing down of the water to supply the city. In Basins 2 and 3 the bottom temperatures are also influenced by the drawing down of the surface. In Lake Cochituate, 60 feet deep, the bottom temperature is lower than in the other reservoirs and is quite constant during the summer. In Chestnut Hill Reservoir and in Basins 3 and 4 the bottom temperatures gradually rise during the summer even though the convectional currents do not reach to the bottom. In Basin 4 the rise is quite slow ; in the reservoirs having less depth the increase is more rapid.

During the winter, when the surface is covered with ice, the temperature at the bottom is higher than at the surface. It varies in the different reservoirs, but in all of them it tends to approach the temperature at which water is densest, *i. e.*, 39.2° F.

Especial attention has been given to the study of the temperature of Lake Cochituate because of its greater depth and because the stagnation phenomena are very marked. For four years observations have been taken at intervals of five feet from the surface to the bottom during the period of summer stagnation, *i. e.*, from about the middle of April to the middle of November. The results of these observations are shown on Plate 2. The curves represent the temperature at different points in the vertical for each month of the year. It will be observed that during the winter months, from December to March, the curves are very much alike. In April the water begins to warm up and the top of the curve bends slightly to the right. In May the water is warmer at all depths and the difference between the surface and bottom temperatures becomes more marked. From June to September the curves are practically the same below the mid-depth. Above that point they differ somewhat, though similar in character. The surface reaches its highest point in July. In October the surface temperature is about the same as for May, but the shape of the curve is different. Down to the depth of fifteen feet the water has practically the same temperature. At that point there is quite a sharp turn, and below a depth of 20 feet the curve is about the same as that of the summer months.

The stirring up occurs in November and for some time after that the temperatures are nearly the same at all depths. In November the bottom temperature reaches its highest point. It will be noticed that from May to October the curves are reversed curves, the point of inflection being found between 15 and 20 feet below the surface. This is the point where there is the greatest differ-

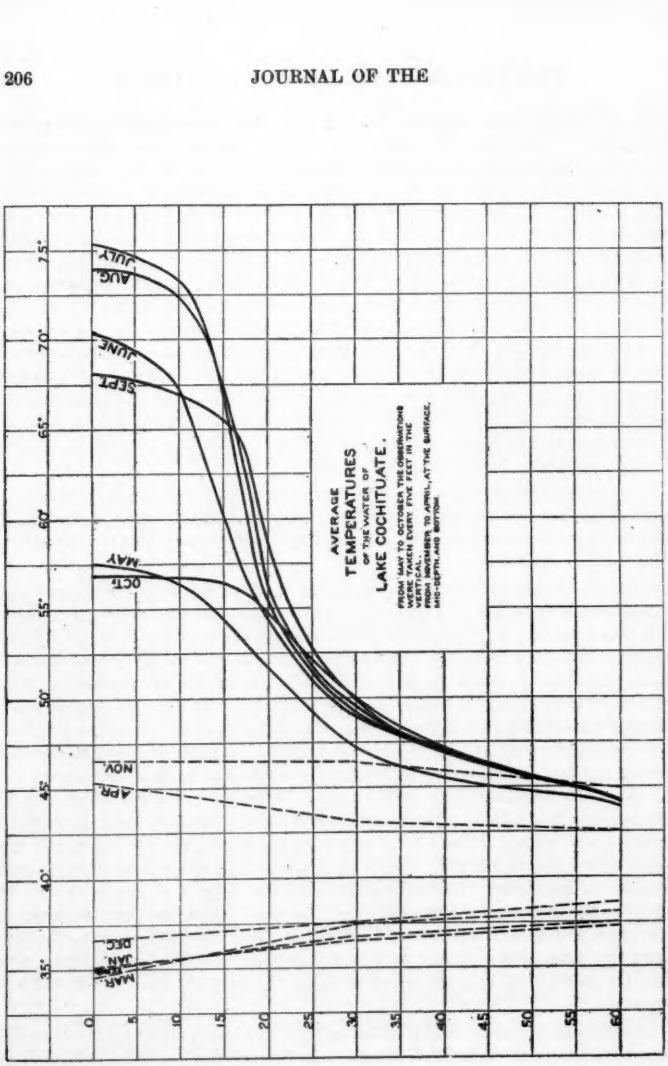

AVERAGE
TEMPERATURES
OF THE WATER OF
LAKE COCHITUATE.
FROM MAY TO OCTOBER THE OBSERVATIONS
WERE TAKEN EVERY FIVE FEET IN THE
VERTICAL.
FROM NOVEMBER TO APRIL, AT THE SURFACE,
MID-DEPTH AND BOTTOM.
JULY
AUG.
JUNE
SEPT.
MAY
OCT.
APR.
NOV.
MAR.
JAN.
DEC.
75°
70°
65°
60°
55°
50°
45°
40°
35°
0
5
10
15
20
25
30
35
40
45
50
55
60

PLATE 2.

ence of density of the water per foot of depth, as is shown by the following table:

AVERAGE DENSITY OF THE WATER OF LAKE COCHITUATE AT VARIOUS DEPTHS DURING THE PERIOD OF SUMMER STAGNATION.

Depth in feet.	Average Temperature during Stagnation.	Density.	Difference in Density.
Surface.	67.1°	0.998359	
			.00075
5	66.6°	0.998434	
			.00090
10	65.6°	0.998524	
			.00384
15	61.8°	0.998908	
			.00545
20	55.1°	0.999453	
			.00223
25	51.4°	0.999676	
			.00158
30	47.9°	0.999834	
			.00020
35	47.4°	0.999854	
			.00022
40	46.8°	0.999876	
			.00027
45	46.1°	0.999903	
			.00015
50	45.1°	0.999918	
			.00008
55	44.7°	0.999926	
			.00006
60	44.4°	0.999932	

The temperature at the bottom during the period of stagnation is not the same every year, and it has been found that the weather during the month of April determines the temperature at which the bottom will remain during the following summer. After the ice breaks up in the spring the water circulates throughout the vertical. The surface and bottom temperatures are then practically the same. As the weather grows warmer these temperatures rise. If there were no wind the bottom temperature would cease to rise as soon as the point of maximum density had been reached; but on account of the wind, and because in that part of the scale the difference in density per degree is very slight, the bottom temperature rises higher than 39.2°. It continues to rise as long as the difference between the surface and bottom temperatures does not exceed about 5° F. But with the first "warm wave" the surface temperature rapidly rises and gains 5° or more over the bottom temperature. The difference of density corresponding to this difference of temperature is usually sufficient to prevent the wind from keeping the water in circulation, consequently the water

at the bottom becomes stagnant, and its temperature remains almost constant at the point where it was when circulation ceased.

In the fall stagnation does not cease until the temperature of the surface has fallen to within about 5° of the bottom temperature. After that point has been reached the first high wind generally stirs up the water to the bottom. This "turning over" usually occurs during the second week of November.

In 1894 the turning over occurred earlier than usual, on account of the cold, stormy weather during the first few days of November, and was especially interesting on account of its suddeness. Fortunately we studied it with particular care, and the thermophone enabled us to determine the temperature at all points in the vertical with great accuracy. Two of the curves obtained with the thermophone are shown on Plate 3. Observations were taken at intervals of one foot in the vertical, and in no case did the reading differ from the curve as plotted by more than 0.1° F. On October 12 the surface temperature was 57.15°. It decreased slightly to 5 feet, and from that point to a depth of 23 feet it was exactly the same. Between 23 and 23.5 feet, the temperature dropped rapidly and observations were there taken at intervals of one inch in depth. Below 23.5 feet the temperature decreased more slowly. The sharpness of the curve at 23 feet was quite remarkable. Readings at that point were several times checked to insure correct results.

On November 7, after the severe snow-storm and during a high wind, observations were again taken with the theremophone. On that day the temperature was uniform at 47.3° to a depth of 46 feet save for a slight increase at the surface, the effect of the sun. At 12 o'clock the temperature at the bottom was 43.5°. Between 48 and 51 feet the temperature was variable, sometimes changing several degrees in less than a minute. Several series of observations were made at intervals of six inches which showed that at that point the water was in a state of commotion and that the temperature at each point was gradually rising. No readings were obtained between 12 o'clock and 2 o'clock. At 2 p. m. the water had practically turned over. The temperature at 51 feet was 46.8°. At 51½ feet, with the coil partially immersed in the mud at the bottom, the reading was 46.5°.

Biological Laboratory.

Before proceeding to the second part of the subject, namely, the effect of temperature on the growth of micro-organisms, it may not be inappropriate to refer briefly to the nature and extent of the biological work which is being carried on at the laboratory at Chestnut Hill Reservoir, Since its establishment in 1889 more than 12,000 microscopical and more than 6,000 bacteriological examinations of samples of water have been made. They cover all portions of the supply, from the brooks at the head of the watershed to the service taps in the city. Samples from thirty carefully selected places are analyzed each week and other localities are visited monthly.

The methods of analysis are those ordinarily used in biological laboratories and are doubtless well known to most of the members of this association. One point of difference, however, ought to be mentioned, namely, the method of stating the results of the microscopical analysis. We have found it advisable to

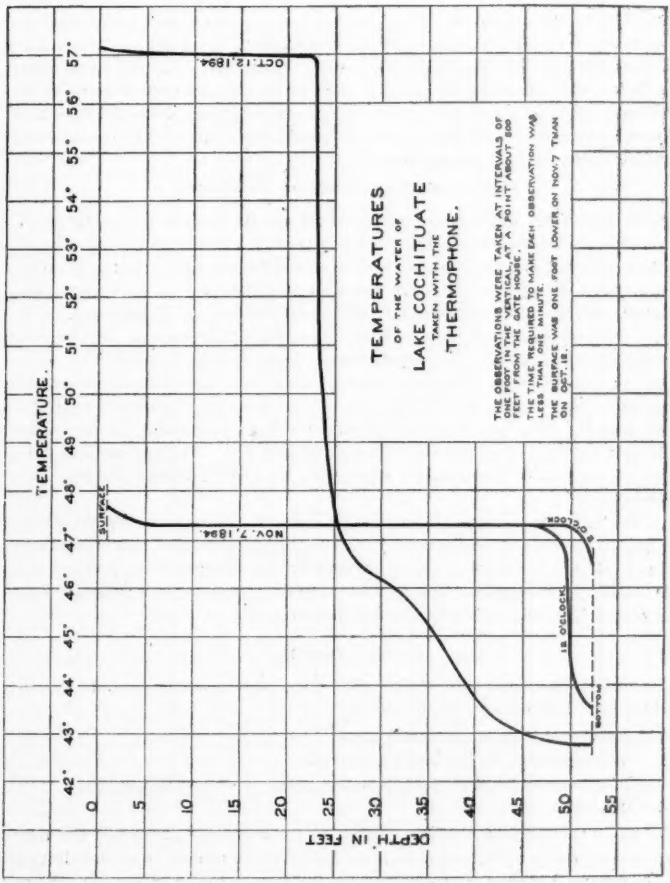

TEMPERATURES
OF THE WATER OF
LAKE COCHITUATE
TAKEN WITH THE
THERMOPHONE.
THE OBSERVATIONS WERE TAKEN AT INTERVALS OF ONE FOOT IN THE VERTICAL, AT A POINT ABOUT 800 FEET FROM THE GATE HOUSE.
THE TIME OCCUPIED TO MAKE EACH OBSERVATION WAS LESS THAN ONE MINUTE.
THE SURFACE WAS ONE FOOT LOWER ON NOV. 7 THAN ON OCT. 12.
TEMPERATURE.
DEPTH IN FEET
OCT. 12, 1894.
NOV. 7, 1894.
SURFACE
5 O'CLOCK
10 O'CLOCK
BOTTOM

PLATE 3.

give the results, not in the actual number of the organisms present, but in terms of a standard unit of size. The micro-organisms vary considerably in size, a *Volvox*, for instance, sometimes containing several hundred times as much organic matter as a *Protococcus*. The "unit system" serves to give us a better idea of the amount of living organic matter present and better enables us to compare the effect of the different organisms on the quality of the water. We have noticed, too, that when the results are expressed in units they compare better with the chemical analyses than when they are expressed in actual numbers. The standard unit which we use represents an area of 400 square microns (1 micron = 0.001 mm.) and our results are expressed in "number of standard units per cubic centimeter."

Effect of Temperature on Organisms.

As to the effect which temperature has upon the growth of organisms it is manifestly impossible to fully treat so vast a subject in the brief space allotted to it in this paper; and I wish to call attention simply to the fact that temperature, directly or indirectly, has a marked influence on the seasonal distribution of the micro-organisms found in surface waters. I do not mean to imply that temperature alone is sufficient to explain their seasonal distribution, or even that it is the most important factor, because recent studies have shown that it probably is not. As is the case with man, so it is with the algae and the infusoria, food supply is of more importance than the temperature of the environment. Man can live, though somewhat uncomfortably, in very warm or in very cold climates, but without food he must die. The amount and character of his food is nevertheless dependent to a considerable degree upon temperature.

In the microscopic world, temperature directly affects some organisms by causing an increase or suspension of their functional activities, and it indirectly influences them by bringing about certain physical changes in the ponds which affect their food supply. It is in this indirect manner that temperature has its greatest influence on their seasonal distribution.

Micro-Organisms.

The micro-organisms which are most abundant in surface waters may be divided into four classes, as follows:

1. Chlorophyceae, or the green algae.
2. Cyanophyceae, or the blue-green algae.
3. Diatomaceae, or the brown algae.
4. Infusoria.

Of these the first three classes belong to the vegetable kingdom; the infusoria are animals. Other organisms are found which cannot be included in the above groups, but they are usually either few in number or of less importance.

The seasonal distribution of these four classes of micro-organisms is shown on Plate 4, where the curves represent approximately the number of standard units of the organisms found in a cubic centimeter of water of Lake Cochituate during the different seasons of the year.

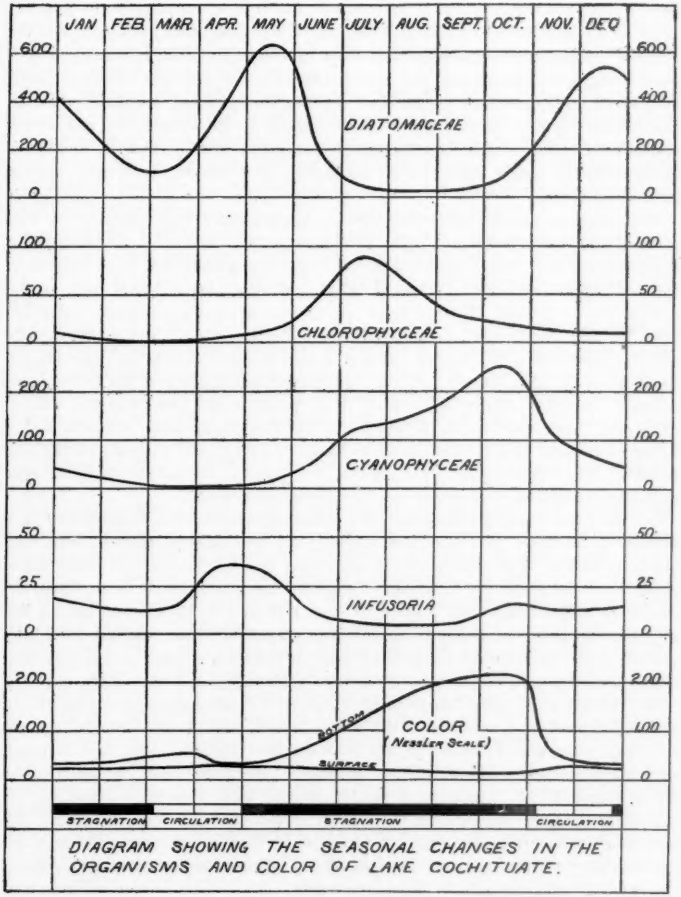


DIAGRAM SHOWING THE SEASONAL CHANGES IN THE ORGANISMS AND COLOR OF LAKE COCHITUATE.

PLATE 4.

Chlorophyceae and Cyanophyceae.

It will be noticed that the Chlorophyceae and Cyanophyceae are most abundant during the warm weather, and that in the case of the former the curve is strikingly parallel to the curve representing the temperature of the water at the surface. These two classes include most of the organisms popularly referred to as "algae." The basis for the distinction between the Chlorophyceae and the Cyanophyceae is a somewhat arbitrary one, founded chiefly on color. The Chlorophyceae are usually green, by reason of the chlorophyll contained in the cells, while, in the Cyanophyceae, the green color is changed to a blue-green, or some darker color, by the admixture of a coloring substance known as phycochrome.

Both classes include a large number of forms, some unicellular, some filamentous, and others having their cells symetrically arranged, or grouped in irregular masses. The long filamentous forms are not often found freely floating in the water, but are attached to the stones, twigs, water weeds, etc., on the shores of the ponds. It is obvious, therefore, that such forms are not often found in the samples of water collected. Their effect on the quality of the water is comparatively slight. Many of the unicellular algae, however, are believed to be intermediate stages in the life history of some of the filamentous forms. This is an important and practical question and one deserving careful research. It is possible that it has a considerable effect on the seasonal occurrence of certain forms, which may, perhaps be thrown off by some of the filamentous plants to multiply in the water, and then, at the proper time or under suitable conditions, to develop into the filamentous form.

As both the Chlorophyceae and the Cyanophyceae contain chlorophyll it is natural to suppose that light and warmth are necessary to their growth, and we find, indeed, that they are most abundant during the summer when these conditions are fulfilled. Extensive growths have frequently been observed during or immediately after a period of hot weather. A calm, warm day in the late summer is the best time to observe many kinds of algae, because then they are apt to rise to the surface, forming, very likely, an unsightly and ill-smelling scum. *Clathrocystis* and *Coelosphaerium* are especially liable to do this.

But all algae do not require warm weather. *Protococcus nivalis*, one of the Chlorophyceae, is found upon the arctic snows, and *Anabaena* is sometimes found growing under the ice of our New England ponds. A marked instance of this has just been brought to my attention. In Laurel Lake, in the town of Fitzwilliam, N. H., *Anabaena* is at the present time growing vigorously. It has become frozen into the ice to such an extent that much of the ice on the lake has a brilliant green color. Fragments of this ice when thrown upon the snow look like little emeralds. Besides being objectional from its appearance, the green ice has a decidedly unpleasant taste.

Diatomaceae.

The diatoms are the most interesting of the micro-organisms found in water. They are single cells whose walls are so impregnated with silica that they have been described as "little glass boxes filled with brown plant matter."

Since they contain chlorophyll we should naturally expect that, as in the case of the other algae, light and warmth would favor their growth. Laboratory experiments tend to show that such is the case. Miquel has stated that the most favorable temperature for the growth of diatoms lies between 68° and 86° F. My own experiments in the laboratory indicate that light and an abundant supply of air are necessary.

When, however, we look at the seasonal distribution of diatoms in surface waters we find that, instead of being most abundant during the warm weather of summer, they are usually found in the spring and fall, when the temperature of the water is between 40° and 60° F. Summer growths are sometimes observed, but, except in ground waters stored in open reservoirs, they are usually of little account.

It is apparent that the direct influence of temperature cannot alone account for their seasonal occurrence. It is not difficult, however, to find its cause, and, as I shall endeavor to show, temperature indirectly plays an important part.

A study of the diatom growths in Massachusetts has shown that diatoms grow best in ponds which have a deposit of mud at the bottom and whose waters contain considerable nitrogen in the form of nitrates. For example, in Lake Cochituate and in Basin 3, diatoms develop regularly twice each year, but in Basins 2 and 4, where the organic matter was removed from the ground before the basins were filled with water, they seldom or never appear. The newly constructed Basin 6 has thus far shown no disposition to support diatom growths.

This relation between the growths of diatoms and the mud at the bottom of ponds throws light upon their seasonal distribution, because the two periods of diatom development correspond almost exactly with those seasons of the year, when by reason of uniform temperature the water is in complete circulation from top to bottom, and when, in consequence, the mud is stirred up and distributed through the water. An examination of the analyses of the Massachusetts State Board of Health reveals the fact that diatom growths usually occur just after a period of stagnation. Out of 12 ponds which are more than 30 feet deep, 11 have a well defined spring and fall growth, while most of the ponds less than 30 feet deep have a spring growth, but usually no growth in the fall. The reason for this apparently lies in the fact that both deep and shallow ponds have a period of winter stagnation, but only the deep ponds are stagnant during the summer. On Plate 5 will be found curves showing the seasonal distribution of one of the diatoms, the Asterionella, in deep and shallow ponds.

The growths that are occasionally found in shallow ponds during the summer and fall are usually quite irregular in their occurrence. I have known instances where diatoms have developed immediately after a high wind, the growth apparently being caused by the stirring up of the bottom. In the very deep ponds the growths usually appear a little earlier in the spring and considerably later in the fall than in the shallower ponds, for reasons that will be apparent when one remembers that in the deep ponds the temperature is quite low during the summer and stagnatian often does not cease until the middle of November.

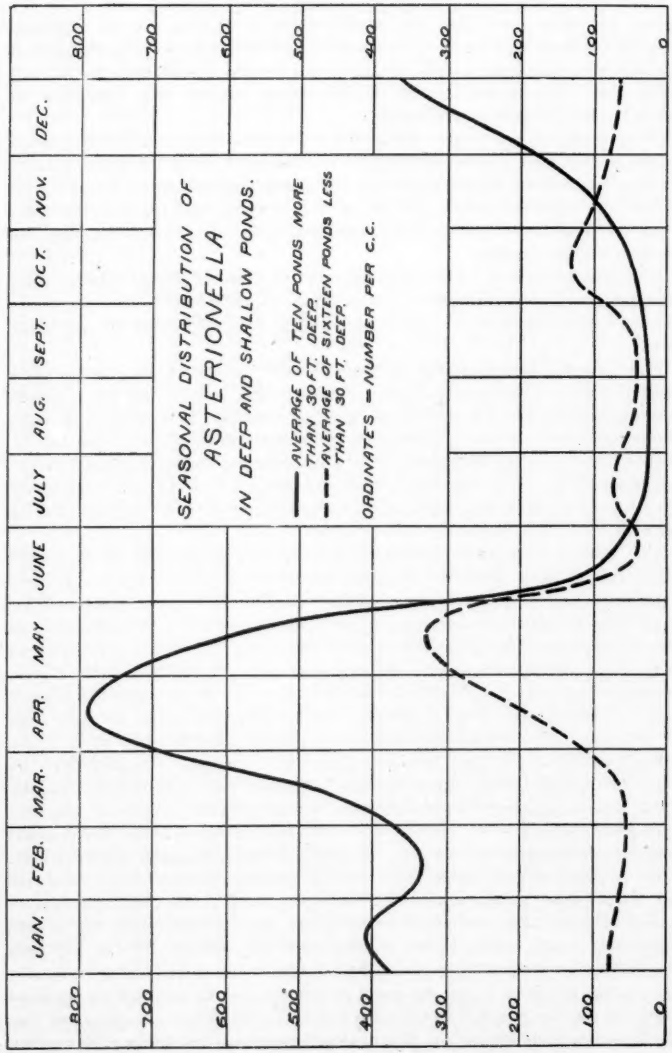

SEASONAL DISTRIBUTION OF
ASTERIONELLA
IN DEEP AND SHALLOW PONDS.
AVERAGE OF TEN PONDS MORE THAN 30 FT. DEEP.
AVERAGE OF SIXTEEN PONDS LESS THAN 30 FT. DEEP.
ORDINATES = NUMBER PER C.C.
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
800
700
600
500
400
300
200
100
0

PLATE 5.

In order to understand why it is that diatom growths occur after the stagnation periods it is necessary to study the character of the stagnant water at the bottom of a pond and the change that takes place when this water is carried into circulation. If we consider Lake Cochituate, for instance, where the bottom is covered with a deposit of organic matter, we find that during the summer some of this organic matter begins to decompose. The process is carried on at the expense of the dissolved oxygen in the lower layers of water, and of oxygen derived from some of the iron compounds. This supply of oxygen, however, is not sufficient and the decomposition is arrested at the "free ammonia" stage. The iron being left in a ferrous condition becomes dissolved in the water and the result is a deepening of the color, which increases on exposure to the air on account of the iron becoming changed to the ferric condition. The increase of color during stagnation is shown on Plate 4. Besides having a high color the stagnant water is usually turbid and often has an offensive odor.

When circulation begins, this water, with its partially decomposed organic matter, becomes thoroughly mixed with the water above it. The bacteria, supplied with plenty of oxygen, change the "free ammonia" to "nitrates," a form in which the nitrogen can be readily assimilated by plants. The color of the water at the surface also rises, as shown by Plate 4.

It is natural to suppose that, at the time when the water turns over, the diatoms, or their spores, are carried up from the bottom, where they have been lying dormant, and that, finding an abundance of food, they begin to develop. Another reason why diatoms grow best during circulation may be that since their cells are somewhat heavy the ascending currents of the water assist in keeping them near the surface, where they have an abundance of light and air. It is known that in absolutely still water diatoms sink to the bottom.

The foregoing facts point out to us the advantage of removing the organic matter from the bottom of a storage reservoir, *i. e.* of "stripping the soil." Because if there is no organic matter at the bottom of a pond, there will be no decomposition during the stagnation periods, and consequently no diatom growths, unless, as is sometimes the case, the water entering the reservoir has a sufficient amount of food material to support their growth.

Infusoria.

The seasonal distribution of the infusoria is much more variable than that of the three classes of organisms above mentioned. In some ponds, as in Mystic Lake, we find them regularly in the summer; in others their occurrence is quite irregular. I think, however, that in the majority of cases, the curve which would best represent their seasonal distribution would be one having a major maximum in the spring, a minor maximum in the fall, and which is much lower during the summer than during the winter.

As in the case of the diatoms, stagnation probably has a considerable effect on the growth of infusoria. They are animals and are therefore supposed to have the capacity to injest solid particles of food and to depend upon such for

their growth. They are also obliged to live on proteaceous, or "ready manufactured" organic matter, not being able, as plants are, to manufacture their food out of the crude materials of the inorganic world.

From this it is a natural inference that, other conditions being the same, the largest number of infusoria will be found at those seasons of the year when the water contains the greatest amount of organic matter in a finely divided state. In some ponds this condition may be found at one season, in other ponds at some other season. We know by the amount of amorphous matter shown in our analyses, that in many of the deep ponds this fine organic material is most abundant during the periods of circulation, and it is doubtless for this reason that the infusoria develop at such times.

Without continuing the subject further, I think that perhaps I have said enough to bring out the point that I wished to make, namely, that while it is undoubtedly true that the temperature of the water directly affects the life of the micro-organisms, it acts chiefly in an indirect manner by bringing about physical changes in the ponds which influence their food supply.

And, in conclusion, I would suggest that if the water works superintendents who are members of this association and who have under their charge a pond or reservoir more than 25 feet deep, would establish a regular series of temperature observations at different depths, they would be adding a great deal to the data which must be collected before we arrive at a full understanding of the growth of the micro-organisms, which are so troublesome in water supplies. In connection with the analyses of the State Board of Health these observations would have great value.

DISCUSSION.

Mr. Forbes. Mr. President, I don't know that I can add much to what Mr. Whipple has said, except that the food supply is the most important element in the growth of algae. I know that in water stored in reservoirs you will find a growth of asterionella and cyanophyceae at any time of the year if the food supply is abundant. You will find in our reservoirs a growth of certain kinds of infusoria in midwinter as well as in summer. The food supply seems to be the most important thing.

Mr. Fitzgerald. Mr. President, it is perhaps natural that I should be interested in these investigations which form a part of the work that we have been carrying on at the sources of supply of the Boston Water Works for a number of years. It is not very difficult to look back ten or twelve years and consider the state of our information on most of these subjects at that time. We then realize the progress that has been made; and yet, however much we may study these matters, there is still always more ahead to be found out. That is one of the beauties of all scientific work. There are are many men who are accustomed to turn up their noses at the idea of there being any practical benefit resulting from the study of organisms in the water, the way in which they

develop, and the quality of the water itself as affected by them. It is not difficult for me to call to mind the many times I have heard men say: "Oh, it doesn't make much difference. Water is water. It is a little thick, to be sure at times, but you drink it and it is all right." The fact is that as we progress and find that we can control the quality of water by our own acts we realize that it is a wicked thing to turn water containing a large amount of organic matter into a city or town for people to drink—children, invalids and people whose constitutions are too weak to overcome the effects of bad water. I think we should realize the responsibility that rests upon us as superintendents and engineers to do all that we can to raise the standard; to insist that a city or town should have good water and that they should judiciously spend enough to make it good.

In connection with this paper of Mr. Whipple's, I think one of the most interesting things to a perfect greenhorn is to take him out into the middle of a deep lake, in the summer, when the temperature of the water at the surface is perhaps up to 80°, anchor over one of these deep holes, ask him to put his hand into the water at the surface—where sometimes I have seen the water so warm that it is almost uncomfortable—then take a bottle and drop it from the same boat at the same place down 60 feet and bring up water so cold and so much like ice water that he can hardly bear to put his hand into it. That enforces on the mind the fact that Mr. Whipple has been setting forth—the great difference in temperature in this stagnation period between the surface and the bottom. Now, of course all the impurities are collecting in the bottom layers during this long period of seven months. The oxygen in the water after a while is all used up but the organic matter keeps on collecting and as soon as all this foul water comes up to the surface in November there is, of course, a vigorous growth, both animal and vegetable, as shown by the rapid rise in the lines on the diagram before you. In the case of a large deep pond, if you have a high dam and gate at the bottom, just before it turns over, you can waste that water at the bottom, and it will have a great effect in keeping the water at the surface pure a little later when the great overturning comes.

I simply mention this as being one of the practical results, and we get them every day in our studies of water supply. The fact is that any knowledge we obtain in this world is a benefit to mankind and it does not do to throw ridicule upon investigations made under scientific conditions.

One thing that we have certainly learned is that you cannot take water from swamps and other places which contain a large amount of organic matter, and turn it into a basin with mud, loam, stumps and other organic matter in it and expect that water to improve. For years and years it will give trouble. I remember very well going back to the period previous to the time when we began a systematic study of our water in Boston, that we had as high an amount of albuminoid ammonia in our basins as .05 parts in 100,000. Today this decimal has been reduced to .018.

I only wish that gentleman from New York was here who made the statement before the Association a short time since that Boston water was not fit for a dog

to drink, and that it was getting worse. I did not happen to be here when he made the statement, but if I had been I am afraid I should have lost my temper, especially when he ridiculed the studies we are making. He simply did not know what he was talking about. Such an attitude is not in harmony with deep scientific knowledge. A man should have found out whether the water is getting worse before he gets up before an association of this kind and states it, or else we can no longer depend upon his statements.

However, that is a little digression. Basins 4 and 6 have furnished some of the best lessons we have learned in connection with Boston's Water Works, because these basins were built in valleys containing a large amount of loam, and we removed it entirely down to the gravel, leaving perfectly clean bottoms. The result is that we have had, even in this period of stagnation, a considerable amount of oxygen present at the bottom, and we have, as a rule, no algae growths to speak of. The line of our organisms is almost a level line on the profile and very low in the scale.

Any one caring to study more in detail the temperatures at various depths during this stagnation period will find in my report in the seventeenth annual report of the Boston Water Works a diagram giving the temperatures for every five feet in the vertical. It will be there seen how little the winds affect the condition and temperature of the water below the 15 foot level, and also what a bad conductor of heat water really is.

In drawing inferences from water temperatures it is necessary to remember that they are largely influenced by local conditions, the extent of the surface exposed to the wind, the depth of the water, its quality and climatic conditions. I have found that the temperatures in Lake Winnipiseogee, for instance, differ very much from those in Lake Cochituate, and even in different portions of the same lake we do not get the same results. In the Swiss lakes, the temperature of the water at a depth of 150 feet is about 10° warmer in the summer than it is in Lake Cochituate at a depth of 50 feet.

MR. COGGESHALL. I think that many of those present would like to hear a description of the Thermophone which Mr. Whipple has used in making his observations.

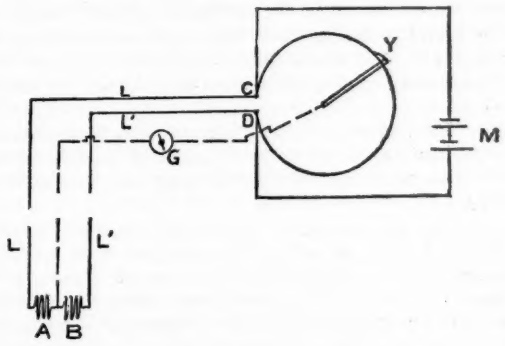
MR. WHIPPLE. The Thermophone is based on the principle that the resistance which a conductor offers to the passage of the electric current depends upon the temperature of the conductor; for instance, if the resistance of a copper conductor at 0°C. is represented by unity its resistance at t°C. will be represented by the equation

$$R_t = 1 + 0.003824t + 0.00000126t^2 + \ldots\ldots$$

It is a singular fact that most pure metals have electrical temperature co-efficients very much like that of copper, but that the alloys have quite different co-efficients; thus for German Silver the co-efficient is

$$R_t = 1 + 0.0004433t + 0.000000t^2 + \ldots\ldots$$

In the Thermophone we have taken advantage of this fact, that different metals have different electrical temperature co-efficients. The accompanying diagram represents the general arrangement of the electrical parts.



A and B are coils of copper and German silver resistance wires placed in proximity. CYD is a slide wire, the two ends of which are connected in circuit with a battery, M. Leading wires from A and B are also carried to the points C and D. Another leading wire is carried from the junction of A and B to a movable contact, Y, on the slide wire, and in this circuit is placed a galvanometer, G. Any one familiar with electrical instruments will recognize this as a modification of the Wheatstone's Bridge, and will see that the galvanometer will indicate zero current when the ratio of the resistances A to B is the same as that of the ratio of CY to YD. A and B having different temperature co-efficients will vary in resistance at different rates with changes in temperature. Consequently there will be a different value of the ratio of A to B for every temperature. This ratio of A to B, which with zero deflection of the galvanometer, is the same as the ratio of CY to YD, may be directly read from a scale placed under the sliding contact Y, or the temperature corresponding to the given ratio of A to B may be marked upon the scale.

It is easily seen that the temperature of the slide wire, CYD, has absolutely no effect upon the reading of the instrument, for being made of one piece of metal which has the same temperature throughout its length, it will rise or fall in resistance at the same rate on both sides of Y as its temperature changes, and consequently the ratio of CY to YD will not vary. The effect of temperature changes on the leading wires will not sensibly affect the readings, because the two wires L and L′ are on opposite sides of the bridge, and consequently balance each other. Compared with the resistances A and B these leading wires are of large size, and in order that they may have the same average temperature they may either be twisted together or laid side by side and covered with braided cotton.

In that form of the instrument used for obtaining the temperature of water we have found it best to inclose the copper and German silver coils, A and B, in a long brass tube of small diameter coiled in a helix and hermetically sealed. The space between the wires and the inner walls of the tube is filled with oil to prevent corrosion and to render the instrument quick setting.

The dial, graduated in degrees Fahrenheit, is placed directly over the disk around the edge of which is wound the slide wire, and it is so arranged that the knob which moves the contact point along the slide wire also moves a hand over the dial.

We have found it convenient in most cases to use a telephone with a current breaker in circuit in place of the galvanometer to show the presence of a current. This is extremely sensitive and has the great advantages of cheapness and portability.

The Thermophone may be used for any purpose where the temperature of a distant place is desired. Experiments on the temperature of the soil at various depths are now in progress, and the instrument is being successfully used in connection with ventilation of buildings, cold storage, incubators, etc. We hope soon to apply it to boilers, chimney flues, etc., for getting high temperatures.

MR. WINSLOW. For my own information, and perhaps the information of others, I would like to ask a question. As I understand it, the resistance of the wire, increasing and decreasing, is shown by the pointer on the instrument. If the resistance coil is at any great distance from the instrument, will the size of the line wires affect the operation of the indicator?

MR. WHIPPLE. No, sir. We have allowed for that. We have made these line wires so large that they have no effect on the reading. That is, we can allow for a range of temperature as high as 100°.

MR. WINSLOW. On the line wire?

MR. WHIPPLE. Yes, sir; and still have no greater effect on the reading, probably, than one-tenth of a degree Fahrenheit.

MR. PORTER. I would like to ask also if the inventors of this instrument propose that it shall be used for very high temperatures?

MR. WHIPPLE. I would say, in answer to that, that we have thought of it, but have not had the time to do much in that line. We probably may do so later on, and I shall be pleased to inform you of the results.

MR. PORTER. Does there appear to be any reason why it cannot be used in such cases?

MR. WHIPPLE. No, sir; it is only a question of minor detail in the arrangement of the apparatus. The principle ought to hold for any range of temperature, but there are certain details in connection with the way the instrument is constructed that would limit it to certain ranges. Probably it can be used quite easily up to a temperature of 350°, and by taking certain precautions to 1,500° or 2,000°. But we have not experimented along that line and cannot tell exactly.

MR. TIDD. Do I understand you that the change of temperature is indicated by the difference in tone you have through the sound of the instrument?

MR. WHIPPLE. No, sir. At one point on the dial there is absolutely no sound in the telephone and that point shows the degree of temperature to which the coil is subjected. As the hand is turned either side of that point a sound will be heard, and this sound will increase in intensity as the hand is moved farther away from the point of silence.

MR. CHACE. I think the Association is very greatly indebted to the officials of the Boston Water Works for their investigation of different questions relating to water supply and for giving us the benefit of their information. I would like to ask Mr. Whipple two questions ; at what depth he draws the line between shallow and deep ponds, and whether his investigations show any relation between the presence of ice on the surface or not, as to the effect on organisms or the condition of the water?

MR. WHIPPLE. Well, in diagram No. 5, I have arbitrarily used the depth of thirty feet. I had to assume some depth, and probably thirty feet is as good as any. It might be twenty-five, perhaps, but, of course, it depends on the locality, the force of the wind, etc. In regard to the temperature, immediately under the ice, the water is naturally slightly higher than freezing ; but as you go down the temperature rises, so that you will find it warmest at the bottom. Ordinarily at the bottom of ponds of forty or fifty feet in depth the temperature is approximately 39.2°. It varies more or less for certain reasons, but ordinarily is at about that point.

MR. PORTER. I would like to ask about this matter of circulation of water —whether Mr. Whipple has found at any time that there seems to be a well-defined current in ponds that do not receive any large stream into them? I remember several years ago in making some inquiries about lakes in the central part of New York, Cayuga, Seneca, etc., that the belief was frequently expressed by men familiar with the lakes, that there was a decided current at certain points. Those lakes are very long, compared with their width, and at the time I supposed that these currents, if there were any, must be due to the action of wind, perhaps long continued in one direction. But I have wondered if anything of that kind had been observed in lakes around here.

MR. WHIPPLE. I do not think we have the data to answer your question. Most of our reservoirs have large streams entering them at one end. As far as the temperature observations go, we have been in the habit of taking them at only one locality in each reservoir. The constant readings which we get at certain depths during the summer would indicate that during the periods of stagnation there is very little circulation in the lower layers.

THE PRESIDENT. I will say that to my mind this illustrates or explains some things that were brought before this Association some time ago in regard to the difference in the quality of water at different depths in reservoirs. I never heard an explanation or any reason given for it before, and I would like to inquire if this is not an explanation or a reason for finding good water and very

bad water at different depths? I think that Mr. Ball of Worcester cited a case here of the Worcester reservoir, where they had to change the location of the gatehouse. The water was very bad at the point taken, and after changing and taking it from a different depth, or locating where the good water was, the trouble was obviated. I would like to ask if this is not a reasonable explanation of that phenomena in reservoirs.

MR. WHIPPLE. There is no doubt but that there is sometimes a great difference in the quality of water at the surface and at a point some distance below. My paper no doubt partially explains what you refer to.

AN EXPERIENCE WITH ANCHOR ICE AND A RECORDING PRESSURE GAGE.

BY

*Chas. W. S. Seymour, Superintendent, Hingham, Mass.

[Read by Mr. Wm. H. Thomas, Feb. 13, 1895.]

In the office of the Water Company at Hingham, directly opposite the main entrance, is an ordinary 6-inch pressure gage, connected through the service pipes of the building with 44 miles of main and distribution pipes, made of wrought iron and cement, and extending from Accord Pond, five miles south, to Hotel Pemberton in Hull, nine miles north of the before mentioned office. Pulling away at this 44 miles of pipe are about 1,500 consumers of various sizes and powers of suction, from locomotives to lobster boilers; from a fleet of harbor steamboats to a two-gallon jug in the locker of a cat-boat; from 25 summer hotels to a tent on the beach.

With a gravity head of only 135 feet above mean high water, and mains of small capacity, the usual results soon followed the introduction of this system, the demands for water became too great for the supply, and the contortions of the before mentioned gage became something wonderful to behold, thereupon a 1,000,000 gallon pumping plant was erected about half way between the pond and the farther extremity at Hull, to draw the water from the pond side of a check valve in the main leading to Hull, and force it into a 400,000 gallon stand pipe on Strawberry Hill, about half way between the pump and Hotel Pemberton.

This worked for a while, but the congregation of so many thirsty individuals at the shore, made it necessary to keep on increasing the daily pumpage to such an extent that the office gage began to get low-spirited again, and the hill places of our Judea began to remonstrate. Then night pumping was resorted to until there was blood on the moon about insurance, and threatened injunctions, until the company scooped in another source of supply, and by means of four miles of conduit pipe and a 350,000 gallon receiving basin, at once stopped the mouths of the growlers and kept the stand-pipe full. Since which time (barring accidents) our gage has had an easy time, usually indicating a pressure of from 45 to 50 pounds, sometimes even as high as 52 pounds, which from its location is the maximum. But alas! with cement pipe who knows "where he is at?" and whenever any interested employees of the company enter or pass through the office, no matter how often, their eyes habitually seek the face of our old friend the gage.

*Mr. Seymour died Oct. 16, 1893.—Ed.

December 26, 1885, was a very cold, snowy Saturday, with a North-east wind which increased towards night to a veritable blizzard. Returning from Boston late in the afternoon, on entering the office my usual glance at the gage informed me that trouble was brewing, and on inquiry I found that the pressure had been falling since four o'clock, and was then below 40 pounds, with a bearish tendency. Now it is no great source of satisfaction to realize that you have a break during a howling blizzard, especially when you don't know that the break is within ten miles; so comforting myself with the thought that the lack of pressure was due to waste to prevent freezing, I ordered the men to report at six o'clock, and in no very contented frame of mind went home to supper.

On my return the fiendish gage seemed to grim with delight as the index steadily pointed to 20 pounds, and our before mentioned hill places began to murmur "no water." By shutting off in succession Hull, Downer Landing, and West Hingham, the trouble was located between the office and the Pond—the gage through all these experiments refusing to wink. Starting one team to examine side streets, with the chief engineer of the Fire Department, who was crazy for fear of fire, I left for the front.

A ride through Hingham is sometimes very delightful, but on this occasion, as on that of Tam O'Shanter's famous ride –

> "This night a child might understand
> The deil had business to his hand."

And in the end we found. What? never a leak, not so much as a tear drop, but the 16" conduit from the Pond into the screen well solid full of sparkling, green, anchor ice, and the well as dry as a last year's crow's nest. Here was richness or rather dryness. Our Fire Engineer was wild and at once attempted to thaw out the conduit, but his heated efforts were without effect, being nothing but words, words, words. Visions of a portable steam apparatus, even of dynamite, floated through my nearly addled brain, until a stupendous idea struggled to the surface, and we all felt relieved.

At that time the independent supply for the pump station had been commenced, and the portion already laid had been connected with the Foundry Pond, so called, a small mill pond near which the conduit ran. This side connection having been made for emergencies only, as the water, while it might put out fire, was unsuitable for the purposes for which water is usually used practically at the beach. My brilliant idea was to start up the pump and put Foundry Pond water into the mains; which we at once proceeded to do.

At the office we left the Fire Engineer and routed out our Mechanical Engineer, (for our present purposes a more useful man, except for words) and with another horse (a white one by the way) five sorry homesick duffers, in as tough a storm as ever blew, broke into the pumping station at "low twelve" on Saturday night.

Boiler empty, pipes disconnected, engine all apart, laid up for the winter, literally coated with white lead and tallow. As soon as possible we got the boiler filled and a fire going. Our white horse had meanwhile been engineered

down some plank into the coal-shed for shelter from the pitiless storm, and soon after, when steam got up and the pop safety valve let go, he reared and fell backwards into the soft coal, in which he rolled until his color did not indicate that there was a red-headed girl within two miles and a half.

We started the pump about five o'clock, but it was an hour before, by the application of hot poultices, we could get the water through the valves with any effect on the gages. But perseverance conquered, and leaving orders not to carry over 50 pounds pressure, out of tender regard for our cement mains, I went for other men to relieve those who had been on duty all night.

The storm had abated and the sun rose clear on a beautiful Sunday morning. Calling at the office I was struck with the peculiarly jolly appearance of our old friend the gage, as the index teetered at 52 pounds, and at once dispatched a messenger to Accord Pond, who reported it frozen over, anchor ice gone, well full, and everything lovely.

Sending word to the pump station to shut down, I went home consoled with the thought that if we had done so twelve hours before it would have been just as well for all concerned.

From all of which we learn that anchor ice, though troublesome at times, is of rare occurrence on sheltered ponds (this being my only trouble with it during 13 years' experience). That it requires for its formation in such situations a sudden drop in temperature, considerably below the freezing point, and at the same time a very high wind, and is usually of brief duration, letting go its grip as soon as the subsidence of the wind allows ice to form on the surface.

And we also learn that though pressure gages, like some of our best friends, may at times cause us considerable anxiety and even be the cause of sleepless nights, yet as life without friends would be hardly worth living, so water works management without well behaved gages would soon become an occupation full of care and anxiety, instead of the jolly, careless source of amusement and recreation, which I hope most of you find it, but which has most certainly *not* been my experience.

A CARD SYSTEM OF SERVICE LOCATIONS.

BY

A. W. F. BROWN, Water Registrar, Fitchburg, Mass.

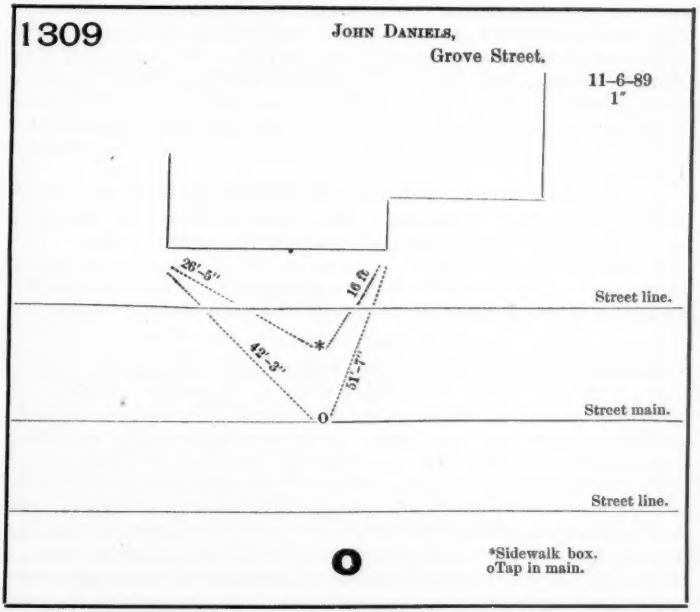
[Read February 13th, 1895.]

The matter of keeping a record of the location of gates, stop cocks, etc., on services in such a manner as to be easy of reference, accurate and not liable to be lost, has received attention from all water works officials. Probably the most common way is to keep them in consecutive order in a book, as put in, showing them by means of a diagram more or less accurately drawn, giving such data as necessary and using an index to find them in the book, or by dividing a city or town into sections and having those in each section together, either by streets or as put in.

The ideal way, it seems to me, is to have a plan of each street, showing all the pipes, gates, etc., with the buildings supplied with water, drawn to a scale large enough to be able to locate a service by scaling off plan to dig for shut off if points from which measurements were taken have been destroyed. The cost of such plans is, however, prohibitory in most cases. I presume some of you are using the same or a similar system as I shall describe, but as it may be a help to some one who is looking for information on this subject, I venture a description. As I have made it up, the style of record for each service is the same as we have always used, but the manner of arranging the services, is the point desired. The system is merely an adaptation of the card catalogue sold by the Library Bureau, of Boston, and used in many of our public libraries.

To describe the set used at the water works office in Fitchburg will give an idea of the room taken and size in comparison with that needed in another place. The cards having the service locations on them are contained in a case of six drawers, said case having outside dimensions of 13 inches deep, 12 inches wide and 16 inches high, and is in our safe, taking about the same room as the books necessary for the same purpose. We have about 4,000 services, and this leaves an allowance for several years' growth. Then, when it is too small, we can add another case and rearrange the cards. The cards are unruled, about 4 by 5 inches, having a hole punched in the lower edge, through which passes a rod, holding them in the drawer and preventing their

falling out or accidental displacement in handling the drawer. A card on the outside of the drawer designates the streets contained therein.



As we record the service, in the upper left hand corner is the service or tap number, taken from the application book. Then, to the right, is the name of the person owning the property, with the name of the street, date and size of pipe under it. The balance of the card is used for a diagram showing the stop-cock in street or sidewalk and points from which it is located, with any other data desired but is not to scale.

The cards are arranged in the drawer by streets, beginning at one end of the street and going to the other end in the same order as the services are laid in the street. The streets are in alphabetical order, and to facilitate finding, cards have been adopted on this plan; service cards are a plain white, initial street card is pink, having a raised edge showing above service cards the name of the street, and at all cross streets or street leading from initial street used a white card with raised edge with the name of the cross street on it. For corporations having large pipes a blue tinted card, raised edge, with name of corporation on it and placed in position that corporation comes on the street.

For instance, I want the location of the stop-cock of John Daniels, Grove street. Taking from the case the drawer having the G's in it, I immediately find the pink guide card with Grove street on the raised portion. Knowing

that Daniels' property is between the cross streets Vine and Prichard, I turn over all the cards before the white guide card showing the position of Vine street, and only have to look over a card or two before finding Daniels' location. Also a corporation has several pipes from different streets and it is desired to save time in looking up one of their services. Take the Parkhill Mfg. Co., for instance; they have services at their mills from Main, Rollstone, Circle, Kimball, River and Cleghorn streets, which will each be found under its initial street and also under the P's headed with a blue guide card with Parkhill Co. on the raised portion will be grouped all of their service locations together.

As new services are put in, the cards for them are placed in their proper street. Some of the advantages of this system are that, once started, it never has to be copied on account of outgrowing the books, is always up to date, arrangement of cards can be varied to suit any new desires, and by using plenty of guide cards it is just as easy to find a card among 10,000 as 2,000 services. As one uses it they will find many other advantages.

DISCUSSION.

MR. CHASE. Mr. President, this interesting paper illustrates some details that occur in the course of experience, which an individual may think are too trivial for any one to care anything about, but which are really of some importance. I have used a card index for about the same purpose—for indexing consumers' accounts. Our books are laid out on a four years' system. They are ruled so that the accounts have to be changed from one book to another only once in four years, giving sixteen lines to a consumer and four consumers to a page. We have a card index which gives the name of the street, the name of the consumer, contains the ledger page, the number of the application—which runs, of course, consecutively in the application book—the number of the service, which runs in the service book, the meter, if it is a metered consumer, and some other data. The first consumers did not have any stop boxes at the curbstone, and that is also noted, and those are being placed in from time to time. Our books are laid out on the street system—that is, the streets are arranged alphabetically in the book, and the consumers are located by the number on each street. As soon as a consumer is shut off for any purpose, the card is immediately taken out of the box and put in another box, where they are arranged alphabetically under street heads, very much as in the box shown by Mr. Brown. So, if a consumer is shut off for any reason for any length of time, within a certain period, say a year or two years, and the property has changed hands; if a person comes in and wants water and gives the number of the street, we know where to look for it, and have the name of the preceding consumer. I find the card system of great use. As Mr. Brown says, it can be kept up to date, and the index is all right all the time. In case of any change of name of the property, the top name is erased and the other written. You can use the same card for three or four changes, and then it can be replaced by another card. It is very inexpensive, and I assure you that any one who gives this plan a trial will find it applicable in a great many cases.

USE OF TAPPING BAND ON CAST-IRON PIPE FOR LARGE CONNECTIONS.

BY

LUCIAN E. TAYLOR, C. E., Boston, Mass.

[Read March 13th, 1895.]

I have often been much impressed with the difficulties that the Superintendents of Water Works in our smaller villages and towns have to contend with, through the lack of skilled labor and the proper tools to accomplish any piece of work that is at all outside the usual routine, so that what would with the Superintendents in our larger cities and towns be a matter of trivial importance becomes a source of anxiety, and the result often is an inferior or patched up piece of work.

As a very large number of the members of our Association are connected with works of quite recent construction and of very moderate size, it will not be amiss at this time to briefly describe an appliance which has been successfully used in tapping pipe for the larger size connections.

I have many times seen Superintendents much perplexed to know how to make connections for 2-inch, 2½ and 3-inch pipes.

Most small Water Works have a number of these connections to make for various purposes, such as motors for printing presses, milk separators, creameries, coffee grinders, elevators and fire purposes.

They usually do not have the appliances and the skilled labor necessary for drilling the hole and cutting the thread essential for such size pipe.

We all know it requires considerable skill to cut the thread properly, and in case of failure we are at our wits' end to know what to do with the opening made. Even when the work is properly done the cutting away of so much metal considerably weakens the pipe at this point.

As far as my observation goes, these connections are made by tapping in 4, 5 or 6 three-quarter-inch or inch stops. These are then connected by lead connections, or a series of them, to the main service pipe. This requires a number of large lead joints, which are quite apt to be very clumsily and unskillfully made, as oftentimes much of the work is done in the trench and the connecting together of the various small pipes with the large one requires considerable skill. This method also has the drawback of cutting a series of holes in the main pipe a few inches apart and in line with each other, thus in some cases quite seriously weakening the main pipe.

About two and one-half years ago I had occasion to attach seven or eight 3-inch blow-offs on 14 and 16-inch pipe, the main supply for the village of St. Albans, Vt.

In this case I bolted to the main pipe a tapping band of cast-iron, with the thread for the outlet pipe already drilled. The casting was made so there was a space next the pipe, which was filled with cement, and around the opening through the band was a heavy rubber packing, molded to fit both the band and the pipe. This made a water-tight joint, and made it perfectly feasible to let on water as soon as the connection was made and before the cement had hardened. After the application of the band, the hole was drilled through the main pipe by use of an ordinary drill.

This method is inexpensive, and instead of weakening the pipe at this point has a tendency to strengthen it. The threads for the attachment of the valves or blow-off pipe are cut by machinery in the shop, and can thus be made more reliable and perfect than if the work were done in the trench; also if the opening through the pipe is irregular or unskillfully done, it does not practically do any harm.

These bands can be applied and all the work done by men who would not have the necessary skill to tap so large an opening in the main pipe itself.

For the preservation of the bolts and nuts from corrosion they should be covered with cement mortar made of cement and sand in about equal parts. These bands are practically the same as are used when tapping cement-lined pipe for services of various sizes. They can always be procured of the Union Water Meter Co., Worcester, and probably of other parties in New England.

In most cases, I believe, large connections can be made with greater safety in less time and with less trouble and expense than by using a number of small taps or cutting in a branch on the main line of pipe. They may be applied to any size or thickness of cast-iron pipe.

HOW TO REDUCE THE EXCESSIVE CONSUMPTION OF WATER.

BY

J. C. HASKELL, Superintendent, Lynn, Mass.

[Read March 13th, 1895.]

In presenting this article I wish to say that I do not attempt to fully cover all of the various points that should be considered in dealing with this question, but think that more attention should be given to this, one of the most important features in a water supply.

When we compare the amount of water used for consumption, we find that in eight of the principal cities of England there was used an average of but 14.82 gallons per consumer (the English gallon, however, contains one-fifth more water than the American), which amount, for purposes of comparison, we will add, making the total of 17.78 gallons per consumer.

When we compare these figures with the amount used in our cities, their significance can be fully seen and the urgent necessity that exists to more nearly approach results that have been attained in other places.

Again, we see in cities near at home a remarkably low rate of consumption — in Woonsocket 21 gallons, Fall River 28 gallons per consumer, which shows conclusively that very low figures may be reached.

In considering the reduction of the consumption I will confine myself to what is brought to my attention in the city of Lynn and the particular causes that contribute to the waste.

The first is to be found in the unnecessary amount used by each consumer.

The second by the improper plumbing, the most prominent feature being the ball-cock in tanks used for the flushing of water closets.

Third. The leaks in main and service pipes.

Fourth. The fact that no charge is made for use of water for public purposes.

Fifth. The regulations require all domestic takers by meter to pay a minimum rate of ten dollars per annum for each house so supplied, which allows a use of 50,000 gallons at the same price as though its use was restricted to 1,000 gallons.

I see no way to reduce to any extent the waste occasioned by the individual consumers, except by measuring the amount of water used and establishing a fixed rate per 1,000 gallons, thus making him directly interested in reducing the amount of water used.

The second source of waste can only be partially met by stringent regulations and a conscientious plumbing inspector.

The third source, leaks in mains, would be much reduced by taking out the remaining portions of our cement-lined pipes and relaying with cast-iron.

Fourth. Use of water for public purposes. There seems to be a disposition on the part of every one to value their property directly in proportion to its cost.

A department of the city having charge of the public fountains, drainage and schools, will indulge in a much more extravagant use of water when its use can be obtained free of cost than when the expense has to be deducted from their appropriations.

Fifth. Adopting a fixed rate for the quantity used.

As bearing upon this waste, and also to form an estimate of the probable reduction in amount if such a regulation was adopted, requiring a fixed rate per 1,000 gallons for all water used, I will submit the results obtained from the amount of water used in ten houses in each class occupied by three different classes of domestic takers. These figures were prepared by the registrar, and represent the amount of water used in one year in houses occupied respectively by one, two and three families, furnished with all modern conveniences and calculated upon the basis of four persons in a family:

	Max.	Min.	Ave.
One family	60,000	18,000	43,580
Two families	45,000	22,500	38,750
Three families	67,000	30,000	52,350

	Max. daily.	Min.	Ave.
One family	41	12	30
Two families	15	7	13
Three families	15	7	12

From these quantities used I infer that the parties interested had a wholesome respect for the expense, and regulated the use of water to come within the minimum limit.

To still farther show how readily the consumer conforms to existing regulations. when it is to his advantage so to do, I will cite three instances observed of meters newly put in service where the second readings show a reduction over the first respectively of 40 per cent., 50 per cent. and 75 per cent.

This saving was not due to leaks repaired, as none could be found, but was entirely owing to the desire to reduce the expense.

This large reduction was probably not as great as it would have been had the meter been placed in position without their knowledge and remained so until the first reading was taken. I consider it as important to reduce the consumption by all practical methods as to reduce the first cost of introducing a water supply, or in increasing the supply when it becomes inadequate.

In the table presented above we find that in both the second and third class houses the minimum rate of consumption is seven gallons; the average was respectively 13 and 12 per consumer. No complaints were made in any case on account of an insufficient supply, and the parties used all of the water for which they were willing to pay, and would have used a less amount if by so doing they would have been at less expense.

The most efficient factor to be used in preventing a waste of water is without question a meter. I will not undertake in the limited time I am expected to occupy today to present any extended argument in favor of their general use. It does not seem to me to be necessary. I will, however, submit my belief that every service should be metered, and that the only classification of water rates should be based on the amount of water used. The only distinction in rates should be based on the purpose for which it is used, it being more valuable for some purposes than others.

I believe that the application of meters to every service, together with a fixed rate by which a consumer is not obliged to pay for water which he does not use, would undoubtedly reduce the consumption as far as domestic services are concerned below a general average of ten gallons per consumer.

The only objection that seems worthy of consideration in adopting this method of reducing consumption is to be found in the incentive given to reduce consumption to such an extent as to affect the cleanliness and health of the community.

This argument, however, is partly met by the answer that the class of citizens to whom it would principally apply reside in tenement houses and suffer the poorest kind of accommodations in all respects. Their water supply being under the control of a landlord, who is conducting the water supply upon business principles and very little regard to the health or comfort of his tenants; buying the water from the city by measurement at minimum rates and doling it out in the most economical manner by throttling the supply to such an extent in some instances as to reduce the consumption to less than two gallons daily per consumer.

While the use of water for business purposes, such as running motors and elevators, cannot be considered as a waste and has always been permitted, such use should be discontinued for the reason that the work can be performed by power generated from electricity at a reduced expense.

If the water used for public purposes was paid for by each department in proportion to its use, we should make a saving of at least 75 per cent. in that direction.

I have no doubt that were the suggestions contained in this paper put in force, the consumption of water would be reduced to less than 30 gallons per consumer.

DISCUSSION.

Mr. Brackett. While I am in hearty accord with the general proposition that the consumption of water in most of our cities and towns is excessive, I must differ with Mr. Haskell in his conclusion that it would be possible, if his suggestions were adopted, to reduce the consumption to less than 30 gallons per consumer, and I will give you an example to illustrate my point. In a city having 30,000 consumers, where there are 3,250 taps and 3,148 meters, the daily average consumption for 1893 was at the rate of 75 gallons per consumer. All the services were metered and the actual amount which was sold was 49 gallons per consumer.

A MEMBER. The 75 gallons was measured on the pumping record?

MR. BRACKETT. Yes, sir.

MR. HASKELL. I would like to ask Mr. Brackett what the minimum rate was, whether there was any inducement for anybody to reduce the amount of water used or not?

MR. BRACKETT. I do not know. A large part of the quantity sold, 25 gallons per day, was used for manufacturing purposes. That naturally would not be at a minimum rate. There were 24 gallons used for domestic purposes. I think you will generally find that where meters are applied for domestic purposes on first-class houses, the consumption will not average more than 24 or 25 gallons per consumer, and in a great many cases it will be very much less. But I also think that after you have metered every service pipe in the town there will be from 30 to 40 per cent. of the water unaccounted for.

MR. HASKELL. I have found in looking over the reports of different cities that when we come to study into what is done in one city and what is done in another we find the same difficulty that Mr. Brackett evidently has. There is a big margin of 40 or 50 per cent. he does not account for. I would like to have him explain how in some of these cities—we will say, like Fall River and Woonsocket—they succeed in getting down to these low figures, while other cities that perhaps ought to do equally as well do not get down there.

MR. BRACKETT. One very great reason in the case of Fall River is that very little water is used for manufacturing purposes. In Fall River the whole manufacturing consumption, both metered and unmetered, the unmetered being estimated, is only about 2 gallons per capita, while in this case which I have just cited it was 25, and in Boston it is 30. And you will find, I think, that the small consumption in other places would be for the same reason. You cannot justly compare the consumption of a city where the metered consumption is 25 or 30 gallons per capita for manufacturing purposes with Fall River, where it is only 2 gallons, and in cases where the house services are metered the domestic consumption will probably be found about the same. I do not wish to argue against the use of meters, because I believe that their use is a very strong factor in reducing the consumption of water, but I do say that the use of meters will not reduce the consumption in all cases, or even in many cases, to 25 or 30 gallons per capita. I do not believe it is possible to do it.

MR. TIDD. I imagine that very much of that variation can be traced in the character of the population of a place. In a large manufacturing town, where there are a great number of mill operatives who live very compactly in boarding houses, there is less water used than there is in a city like Newton, where there are large gardens and lawns, and where the population is composed of a class of people who use water plentifully for all purposes. I imagine if you traced the conditions in these places that have so small a consumption they will be found to be those manufacturing towns where the population is packed in closely together. Take Woonsocket, for instance, as a good example of that. And I think you will find it so in all cases. I know, in fact, that the character of the population has much to do with the amount of water that is used.

MR. CHACE. I have one case in my mind in Taunton which I will mention, to meet the suggestion made in the paper that the tenants are sometimes not well used by the landlord. It is my experience that sometimes the landlord is not well used by the tenant, and that where the landlord pays the bills the tenants oftentimes waste the water. Now, here is a case as an illustration: In a case where the supply of three buildings occupied by six families and a store was taken through one meter the consumption was found to be 2,700 cubic feet per month. The landlord questioned the accuracy of the meter, but on placing two additional meters, so as to subdivide the supply, they were found to agree with the main meter. By setting meters in the pipe supplying each family in one of the houses it was discovered that one of the tenants was using the greater portion of the water, and the consumption was finally reduced from 2,700 cubic feet to 840 cubic feet per month.

MR. CRANDALL. I would like to ask Mr. Chace who bore the expense of that experiment.

MR. CHACE. The water department, for its own satisfaction.

MR. HASKELL. I would like to suggest to Mr. Chace that his illustration shows that the landlord was looking sharp after the waste of water.

MR. CHASE. If all the water is metered, I do not see as it makes any difference on business principles whether you reduce the per capita consumption or not. People who undertake to sell water as a money making business like to have the water used. I call to mind one case illustrating the relations between landlord and tenant, where the bill was something like $25 a quarter for a building with three or four tenants, and two or three stores. The landlord was complaining all the time about the meters being wrong, but after a while he found out that one of his tenants opened the faucets so as to have the water run continuously, in order to work out a grudge he had against the landlord. He thought that would be a nice way for him to get even. I think it cost the landlord about $30 in the course of a year. As soon as he discovered it and got rid of his tenant, the bill came down to a proper amount, and after that he was willing to believe that meters might be right.

We have some 200 meters supplying private houses, and we find an allowance of 135 gallons per day about right; very few families use over that amount of water. That permits a moderate amount to be used for the garden, it is a class of house with water closets and a bath room, and the people are reasonably clean. I suppose, with servants, most of them have one or two negroes around, the average would be six persons to a family; but as an offset the washing is not done on the premises, which, of course, would make a certain amount of saving. That with an average of five persons would be about 27 gallons per day per consumer. That is a very fair estimate for the use of water in a southern town, where there is certainly a much larger amount of bathing done than there naturally is in a northern city. It shows to what the consumption can be reduced for household purposes.

MR. MCNALLY. We had a case in our city similar to the one which Mr. Chase mentions, and in reference to what the last speaker said, that it does not matter how much water is used when it is all metered, I would say, I

think it does. It matters in this way, that the more water wasted, the more abuse the registrar has to stand when the consumers come to pay the bills. In the case to which I refer the building was occupied by four tenants, who were considered a very nice class of tenants. We had a meter on the building for six months and the bill was $72. Of course, the meter was wrong. (Laughter.) By reading the meter every Monday morning for four weeks, the consumption was reduced to a reasonable amount. But it was six months before we discovered the cause of the trouble. I agreed with the owner that the amount of water used could not be used in any proper way, but to place where the waste was you could not. But one day we learned that one of the tenants had been in the habit of leaving his faucet open in order to get square with the landlord. We have at the present time a minimum rate I think as low as any place, $6 for a dwelling without regard to size. And I find that the small consumers when their bill for six months is twenty-five cents over $3 will complain, while when the minimum rate was $10 they were perfectly satisfied if they could keep within that limit.

MR. PORTER. Just a word, showing how the landlords sometimes manage. I remember having seen a number of cases in this city where tenants' water-closets on the second floor were flushed only by a sink waste-pipe from the floor above. That seems to me a good example of economy on the part of the landlord.

MR. FULLER. I think there is one reason for reducing the waste of water, which has not been mentioned, and that is, that many towns are now using nearly all the water that is available, and to increase the supply would cost a considerable amount of money. This was the situation a few years ago in the town of Wellesley. In 1890 we used about 93,227,000 gallons. Then we adopted the use of the meters. It was not until last year that we had them on every tap, and our consumption for 1894 was 67,900,000. We have now 647 services; in 1889 the number was 503. We have reduced our consumption about 30 per cent., while our consumers have increased 10 per cent., and even in such a dry season as last summer, we had water enough.

We have a minimum meter charge of $6, which allows for the use of 16,000 gallons, and any used in excess of that is charged at the rate of 25 cents per thousand gallons. This rate is rather low, but with us it is not so much a question of income as to make the amount of water we have available, sufficient to meet the demands of the town. Our population in 1890 was somewhere about 3,600; it is somewhat more now, but on the basis of 3,600 the consumption would be about 50 gallons per inhabitant.

MR. HASKELL. While I do not believe in reducing the amount of water to a point that would in any way interfere with the health or cleanliness of the city, I do think that the water works should be managed in the most economical manner, and I see no better way to do this than to reduce the consumption of water to as small an amount as possible.

MR. WASHINGTON. As a member of the Tenement House Investigation Committee appointed by the legislature of New York recently, I may say that we took a census of 42,000 tenements in New York city, and in one particular

territory we found a population as great as 1,000 to the acre, which is more dense than in any other place on the face of the globe, not excepting Bombay or Calcutta, or Constantinople, or Budapesth which is very thickly settled, or Berlin. We took a census of 255,000 people in the Hebrew section, and of that number I might ask the members of the Association to guess how many have access to baths. There were 309 out of 255,000 who had access to baths, showing how small the consumption of water must have been for that quarter of a million of New York's inhabitants, at least for washing purposes. Of the 42,000 tenements, of which we took a census, although this fact was not exactly determined, I will venture to say that at least 25,000 had only one tap in the hall on each floor. There was no running water in the rooms at all, and all the tenements had to go to the hall to get water from the tap, and then had to carry the water a certain distance, which would also tend to minimize the consumption. The sanitary arrangements for a great many of the older tenements consisted merely of a water-closet in the yard; consequently only the most serious calls of nature would be attended to by going to the yard, and the rest would be attended to by means of a pan in the room, which was emptied into the sink. I might go on multiplying situations, which we found to be very serious, and in fact horrible, in a great many cases, to show that there is a very large portion of the people in New York who must use a comparatively small amount of water. The Trinity Corporation, which owns a large amount of property in New York, have in many of their tenements no water, but simply a hydrant in the yard. We got a law passed by the legislature compelling the putting of water on every floor in a tenement house, and they fought that on constitutional grounds, and it was at first decided that it was unconstitutional, but that decision has recently been reversed, and it has now become a law that landlords must put water on each floor. In a great many cases we found water had to be carried up two or three flights, which tended to minimize the consumption still further.

The recent consumption of water in New York has been about 200,000,000 gallons a day, which shows that the amount per capita used for manufacturing purposes must be very large indeed, or the amount wasted must be excessive to an extreme degree, when we have such a large proportion of the population using such a small amount of water for domestic purposes.

Mr. Walker. This is an old subject. I have heard it discussed a great many times, still it is very interesting to me, because I have had more or less trouble with meters. Complaints are often made that the meters do not register correctly, but in all cases where we have tested them we find the meter tells the truth. I don't see, however, how you can meter a service pipe and read the meter and keep it in repair unless you receive about $15 a year. That may seem queer to some of the gentlemen here, the gentleman from Lynn, for instance, but I don't see how you can take care of the meter for less money. We furnish our own meters in Manchester. If there is anything that causes dissatisfaction it is a meter, because people will all tell you they have not used the water. For example, a man came into my office one day and said he

wanted to have a meter put on. Said I, "What do you want to have a meter put on for?" He said he paid $15 a year now. Said I, "You don't have to pay but $15, and suppose you have a meter on, you will have to pay $12, for that is the minimum rate." Well, he said he might as well have that $3 as to give it to the city. "Well," said I, "you can have it put on, but I had rather pay double and not have a meter. I should advise you not to have it put on." Well, he said he would have it on, because there was nobody but himself and his wife and one child, and they didn't use any water to speak of. So we put a meter on, and for the first three months the bill was $8, or at the rate of $32 per year. Down he came to the office, and said he: "You are robbers. There is no mistake about it; everybody says you are robbers. You have got the name of being robbers." Said I; "You go back home and see if that hand is going round, and if you see it is don't come to me, but you go and look; take a lantern and go down cellar and look." I saw him down town a while afterwards, and he acknowledged that the hand was going. "Well," said I, "that tells the story," and he was obliged to acknowledge that he did use the water. Now, we have got some 3,000 meters in Manchester, but if there is anything that causes trouble, tribulation and vexation of spirit, excepting cement pipe, these meters do.

MR. HASKELL. I would like to ask Mr. Walker if the trials and tribulations he has been put to on account of meters have not been almost entirely due to the desire of the people who come to interview him to reduce the amount of payment for water?

MR. WALKER. That is right. I won't argue against that statement. (Laughter.)

MR. WASHINGTON. I might accentuate what I said as to the extensive use of water in New York by stating that in our investigation we discovered that nearly 75 per cent. of the people in New York lived in tenements, the legal definition of tenement there being a house that is occupied by more than three families. Throwing out the better grade of apartment houses, which approach hotels, we found that 63 per cent. of the entire population was living in tenements, and in a large number of cases we found from 8 to 14 persons living in 2 or 3 rooms; and, as they had to take their water from a tap in the hall, or bring it from the yard, of course the consumption per capita is very small indeed. In many of the cases where they had bath-tubs, we found the tenants used them for coal bins or general storage purposes.

MR. WALKER. I would like to know if there is any gentleman here who has tested a meter and found that it did not register against the city?

MR. HASKELL. I would like to answer Mr. Walker's question, and I can tell him I have repeatedly tested meters, and almost without any exception, whatever error there was found was in favor of the consumer instead of the city.

MR CHASE. I can relate a little incident which may throw some light on this subject. A meter, which had been supplying a manufacturing concern whose bill was about $150 per year was taken out at the end of three or four years and it was found to be over-registering something like five per cent. The machine was sent to the maker and the report came back afterwards that one of

the change gears had been stamped wrong. In this case the manufacturer had been robbed but the punishment seemed to fit the crime, for he was a bad man and left off business owing something like $50 or $60 for water. That is the only case I know of where a meter registered against the consumer, and in that case the error would have been discovered originally if the meter had been tested before being set. I am under the impression that my namesake from Taunton stated in his report of a year or two ago that he had discovered some meters that registered against the consumer. Perhaps he can tell us something about it now.

MR CHACE. Mr. President, our report for this year is just issued, and will be sent to the members of the Association within a few days. That contains the results of 878 tests made during the past year. We test a meter, sometimes for the full capacity, sometimes for a quarter-inch or eighth-inch stream, and sometimes smaller, but generally for five-eighth and three-quarter meters we take quarter-inch and one-eighth inch streams, sometimes the full stream. In most cases the meters are in favor of the consumer, but I have repeatedly seen cases where they register against the consumer by a small percentage. Five per cent. is a large percentage to be against a consumer, and that is usually in the case of new meters which are so made that while they are new they will over register somewhat in order to make allowance, I suppose, for the wear which will take place, so that after the meter has been in use a while it will under-register. But there are cases where meters over-register, although as a general rule they are in favor of the consumer.

MR. CRANDALL. I would like to ask Mr. Chase if I understand him to say that a meter tested and recording accurately, or within a prescribed limit, in his opinion can ever register in favor of the city. If they are once right, can they, in your opinion, become wrong in that direction?

MR. CHACE. If it registers correctly in the first place, it will continue to do so, with some exceptions which I do not care to discuss at the present time.

A DESCRIPTION OF THE WATER WORKS AT WEBSTER, MASS.

BY

FRANK L. FULLER, C. E., Boston, Mass.

[Read March 13th, 1895.]

Webster is a town of about 7,000 inhabitants, situated about 16 miles south of Worcester, on the Norwich & Worcester division of the New York & New England Railroad, and also on the Webster branch of the Boston & Albany Railroad.

The industries of the town are large woolen mills owned by Mr. H. N. Slater, and the population is made up to a considerable extent of his operatives, who are largely Poles, French and German.

The accompanying map shows the system of pipes, also the well, pumping station and stand-pipe.

It was decided to take the water from a collecting well located near Lake Chaubunagungamaug. This is rather a long name for a very beautiful lake. It is said to be a contraction of the old Indian name said to be spelled thus: Chargoggagoggmanchauggagoggagungamaugg.

In order to determine the best location for the well, 10 2½-inch test wells were driven in various places by Mr. Daniel Russell, member of this Association. The best results were obtained at the point at which the well was afterwards built, as shown on the map. The material at this point was coarse sand and gravel. The other test wells, which were driven 300 or 400 feet from the lake and south of the location adopted, showed the material to be a fine sand, from which little water could be obtained.

THE WELL.

The specifications called for a clear diameter of 25 feet at the bottom and 26 feet at the top.

Bids were received, stating price for a well 20 feet deep complete. In case it was thought desirable to have a deeper well, the price for each additional foot up to a total depth of 30 feet was also given. With this arrangement the well could be stopped at any depth between 20 and 30 feet, according to the yield of water.

The prices of the bidders were as follows:

Thomas Hennessey, Jefferson,

1st 20 feet.	For 5 feet additional per foot.	For 5 feet additional per foot.	Total for 30 feet.
$6,940 00	$500 00	$750 00	$13,190 00

Nahum Perry, Attleborough,

1st 20 feet.	For 5 feet additional per foot.	For 5 feet additional per foot.	Total for 30 feet.
$8,000 00	$300 00	$500 00	$12,000 00

At the depth to which it was expected the well would be built Mr. Hennessey was the lower builder, and the contract was awarded to him. It was finally concluded to go to a depth of 30 feet. At this depth Mr. Perry's price would have been the lower.

The well is located about 300 feet from the lake. The excavation was made by driving two-inch plank sheeting outside of ribs made of three thicknesses of 3-inch spruce plank sawed to the proper circle, and spiked or bolted together. Sometimes another thickness was added. The sheeting was in two sets, as plank could not be obtained long enough to extend to the bottom, and it would have been difficult to have driven them, even if such lengths could have been found.

The water was removed by two 6-inch centrifugal pumps. The yield at a depth of 30 feet was at the rate of about one million gallons in 24 hours.

After the excavation had been made, a dry rubble masonry wall was built within it. This wall was 5 feet thick at the bottom. At a height of 3 feet, this thickness was reduced to about 3 feet 8 inches by an offset on the inside. The shoulder thus formed supports a circular brick lining 12 inches thick, laid in cement. The dry rubble wall is reduced in thickness, so that at the top it is 2 feet.

At the top are laid heavy coping stones, 3 feet wide by about the same length. These bind the stone and brick work together and make a foundation for the wooden roof.

The upper 4 feet of rubble wall is laid in cement.

The well is similar in construction to that built at Waltham in 1891, and described in Vol. IV., No. 4, of the New England Water Works Association Journal. With that paper is a sectional drawing showing the construction of the well.

The well here described was begun in August, 1893, and completed in November of the same year. It was afterwards covered with a wooden roof costing $320.

Cast Iron Pipe.

Proposals were received for about 760 gross tons of 16, 14, 12, 10, 8 and 6-inch pipe, delivered on the cars at Webster, and the contract was awarded to the Jackson & Woodin Manufacturing Co., Berwick, Pa., at the following prices:

16-inch, 110 lbs. per foot.....$27.75 per ton.
All other sizes..... 26.75 " "

Pipe Laying.

On July 28th, the proposals on following page were received:

PROPOSALS FOR PIPE LAYING, WEBSTER WATER WORKS.

	Laying 3000 feet 16-inch Pipe	Laying 40 feet 14-inch Pipe.	Laying 6,600 Feet 12" Pipe.	Laying 5,500 Feet 10" Pipe.	Laying 5,500 feet 8" Pipe.	Laying 12,700 Feet 6" Pipe.	Laying 1,100 Feet 4" Pipe.	800 Cubic Yards Rock Excavation.	20 Connections with Old Pipe.	Extra Earth Excavations.	Total.
Thomas Hennessey, Jefferson.	$0.50 1500	$0.40 16.00	$0.38 2508	$0.32 1760	$0.27 1845	$0.24 3048	$0.18 198	$3.75 3000	$3.00 60	$0.40	$13,575 00
L. A. Taylor, Worcester.	0.49 1470	0.42 16.80	0.35 2310	0.32 1760	0.28 1540	0.25 3175	0.21 231	3.75 3000	8.00 160	0.50	13,662 80
J. T. Langford, Boston.	0.41 1230	0.38 15.80	0.35 23.10	0.32 1760	0.29 1595	0.26 3302	0.23 253	4.00 3200	0.50 10	0.50	13,675 80
F. A. Wellington, Webster.	0.65 1950	0.52 20.00	0.45 2970	0.36 1980	0.30 1650	0.25 3175	0.21½ 236.50	4.00 3200	0.50 10	0.75	15,192 30
Moore & Co., Boston.	0.36 1080	0.36 14.40	0.36 23.76	0.36 1980	0.36 1980	0.36 4572	0.36 396	4.50 3600	10 200	0.75	16,198 40

The work was awarded to Mr. L. A. Taylor, of Worcester, member of this Association. The pipes were filled and tested the latter part of December. But few leaks were found, and these were promptly repaired.

STAND PIPE.

The contract for erecting a wrought iron stand pipe 30 feet in diameter and 100 feet high was awarded to the Cunningham Iron Works Co., Boston, without roof for $10,870. A rather flat conical wooden roof was adopted, the cost being $325.

The stand pipe rests on a foundation of rubble masonry laid in cement. It is about 6 feet deep and has an average diameter of 31 feet.

The force main connects with the bottom by means of a 16-inch quarter bend.

A brick arch extends a short distance under the tank or stand pipe, and through this the force main and quarter bend are laid.

The stand pipe is composed of 20 courses of refined plate iron of 50,000 lbs. tensile strength.

The shell is connected to the bottom by a 6x6x$\frac{7}{8}$ inch angle iron, riveted to the outside of the shell.

The horizontal seams in the first ten courses and all the vertical seams are double riveted. The horizontal seams in the second ten courses are single riveted.

The capacity of the stand pipe is 5,288 gallons for each foot in depth, or 528,770 gallons for the whole height.

The bottom of the stand pipe is $\frac{3}{4}$ inch in thickness. The different courses are of the following thicknesses in inches:

1st and 2nd	13-16	11th and 12th	8-16
3rd " 4th	12-16	13th " 14th	7-16
5th " 6th	11-16	15th " 16th	6-16
7th " 8th	10-16	17th " 18th	5-16
9th " 10th	9-16	19th " 20th	4-16

A vertical iron ladder on the outside extends from a level of 12 feet above the ground to the top.

A balcony 30 inches wide, supported by iron brackets, extends around the top.

The stand pipe is about 40 feet from the line of force main from the pumping station to the town. About 12 feet of this distance consists of 12-inch pipe with a 12-inch gate in the middle of it. At either end is 16-inch pipe to the force main and to the tank. Around this piece of 12-inch pipe is a 14-inch by pass, with a 14-inch check valve in the centre, and opposite the 12-inch gate.

This check valve opens from the stand pipe.

By partially closing the 12-inch gate additional pressure is thrown on the distribution system. In case of fire, when the water is low in the stand pipe, the 12-inch gate can be closed and water supplied by direct pumping. When the pump is stopped, the check valve opens and the town gets the benefit of whatever water is in the stand pipe.

Gates and Hydrants.

The bid of the Chapman Valve Co., of Indian Orchard, Mass., for water gates was accepted, and fire hydrants were furnished by the Ludlow Valve Manufacturing Co., Troy, N. Y.

The dimensions of the hydrants are as follows: Diameter of inlet or seat ring 4½ inches; diameter of stand pipe, 6¼ inches; two 2½ inch nozzles; distance from top of six-inch branch pipe to sidewalk level, 5 feet, and diameter of bell connection, 6 inches.

Iron extension gate boxes and service boxes were furnished by Messrs. Bingham & Taylor, Buffalo, N. Y.

Pumping Station.

The pumping station is located east of the Southbridge branch of the N. Y. & N. E. R. R., about 300 feet west of Lake Chaubunagungamaug.

Plans and specifications were prepared by Mr. E. N. Boyden, architect, of Boston.

The work was awarded to Mr. F. A. Upham, of Webster, for the sum of $5,000.

It is a neat and substantial brick building, with a brick chimney 75 feet high. The engine room is 29 feet, 10 inches × 28 feet; the boiler room 35 × 30 feet, and the coal room 20 × 30 feet 2 inches, all inside measurements.

The boiler room connects with both engine and coal rooms. The engine room has a hard wood floor. The boiler room has a Portland cement concrete floor. Under the engine room is a basement about four feet deep, containing suction and discharge pipes, steam traps, etc. The brick work, both inside and out, is laid in red mortar. The roof is covered with slate.

Coal can be easily unloaded from carts into the coal room, which has a capacity of about 125 tons.

The engine room contains an indicator operated by a float, showing the height of water in the well, which is about 35 feet away.

It should also have an electric recording instrument to show and record the height of water in the stand pipe. It would also be extremely useful and convenient to have a similar indicator in the water commissioners' office.

With this indicator at the pumping station, the engineer could fill the stand pipe and have no fear of overflowing it. The weekly cards from the dial would show the exact time of pumping and height of water at all times, day and night.

Pumping Plant.

The specifications for pumping machinery called for a pump capable of raising 1000 gallons per minute into the standpipe, the maximum lift being about 200 feet. The engine to be compound, condensing. The plant to include two boilers, either to be capable of supplying the necessary steam to do the required work.

The contract was awarded to the George F. Blake Mfg. Co., Boston. Duplex pumping engine, having steam cylinders, 11 and 22 inches, and water cylinder, 12 inches in diameter, all of 18 inches stroke. Two boilers with shell 16 feet 2

inches long and 54 inches in diameter, having 72 three inch tubes 15 feet long, price $8,560.

These figures included feed pump, air pump, boiler foundation, fire tools, etc.

The plant has an independent air pump and condenser, arranged to take water from a small brick well connected with the lake or from the collecting well. Condensing water can also be supplied under pressure from the mains.

The feed pump is of ample size, and is arranged to pump the feed water from a hot well supplied by the overflow from the condenser or from the well supplying the condenser. It can also take water from the main.

The feed water can be passed through a heater, thereby utilizing some of the heat of the exhaust steam from the low pressure cylinders.

The discharge pipe from the pump is provided with an Ashton relief valve and a check valve.

A test was made May 8, 1894, with the following results:

Pump, 11 × 22 × 12 × 18 inches, duplex.

Plunger rods, 2¼ inches diameter

Time of test, 11.30 a. m. to 5 p. m., or 5 hours and 30 minutes.

Coal burned, 800 pounds; weight of a gallon of water taken as 8.34 pounds.

Total number of revolutions (by counter), 9,922, or 39,688 strokes.

Averge length of stroke, as measured, 1.524 feet, or 18.288 inches.

Average water pressure, by gauge, during test, 73.2 pounds.

Correction (gauge found to read too much) 2.

Corrected pressure, 71.2 pounds, equivalent to a head of 164.47 feet.

Average distance from centre of water pressure gauge to water in well during test, 21.47 feet.

Total lift, including friction and suction, 185.94 feet.

In order to determine the amount of water delivered by the pump at each stroke, the town was shut off, and all water for 1 hour and 15 minutes was pumped into the standpipe and accurately measured. During this time the surface of the water in the stand pipe was raised 14.90 feet, amounting to 78,786.04 gallons, the stand pipe being 30 feet in diameter.

During this time the pump made 9,532 strokes, of an average length of 1.52 feet, or a total piston travel of 14,488.64 feet; 78,786.04 divided by 14,488.64 equals 5.438 gallons for each foot of piston travel, or 8.157 gallons for a stroke 1.50 feet long. Using the figures given above the theoretical displacement would be 8.658 gallons. There is therefore a slip of 5.78 per cent.

The average length of stroke for the whole run was 1.524 feet. 1.524 × 5 438 × 8.34 (wt of 1 cubic foot of water)=69.115 lbs. lifted at each stroke.

The duty is therefore,

Wt. per Stroke.		Number of Strokes.		Lift.			
69.115	×	39,688	×	185.94	×	100	=63,755,000 ft. lbs. per 100 lbs of coal.
				800			
				coal.			

The duty guaranteed by the makers was 55,000,000 pounds. They have there-

fore exceeded that duty by 15.9 per cent. It should be said that the test was too short to get the most accurate results.

During the first hour and fifteen minutes, while the water was being pumped into the tank, the average pumpage was 1050 gallons per minute. For the whole time the average per minute was 997 gallons. Steam varied from 63 to 75 pounds. Most of the time it was from 65 to 66 pounds.

Hydrants were flushed out, and all leaks in the mains were repaired before the middle of February, and the counter placed in position on the pump, and a record kept from February 20, 1894, to date.

Pumping station record from February 20, 1894, to January 1, 1895:

Month.	Number of hours run.	Number of gallons of water pumped into Standpipe.	Weight of coal burned.	Number of cords wood burned.
February	39½	2,879,195	9,625	
March	126½	9,143,926	30,770	
April	78¼	6,242,184	23,375	
May	97¼	7,198,243	28,775	
June	98	7,129,439	17,100	9½
July	114¼	8,066,559	23,300	9
August	99¼	6,845,373	31,800	
September	150½	6,243,293	29,225	
October	81¼	5,285,816	23,925	
November	74¾	4,743,663	22,825	
December	77¼	5,112,975	25,300	
	1036¾	68,890,666	266,020	18½

The cost of construction to December 31st, 1894, was $106,042.86. An item of $12,564.68 included in the above is for old pipes in the ground belonging to an old system owned by Mr. H. N. Slater, but as a small amount only of the pipe will be used it is hardly fair to include this amount in the cost of the works.

Hydrant pressure varies from 55 to 115 lbs. per square inch.

January 1, 1895, there were 490 taps, of which 96 were metered. It is probable that soon a much larger proportion will be.

The water is of most excellent quality, as shown by the analysis by the State Board of Health, hereto appended.

COMMONWEALTH OF MASSACHUSETTS, STATE BOARD OF HEALTH, WEBSTER,

WATER ANALYSIS.

(Parts in 100,000.)

NO.	DATE OF		APPEARANCE.			ODOR.		RESIDUE ON EVAPORATION.			AMMONIA.				Chlorine.	NITROGEN AS		Oxygen consumed.	Hardness.	Iron.
												Albuminoid.				Nitrates.	Nitrites.			
	Collection.	Examination.	Turbidity.	Sediment.	Color	Cold.	Hot.	Total.	Loss on Ignition.	Fixed.	Free.	Total.	In Solution.	In Suspension.						
11777	1894 Feb 15	1894 Feb 16	None.	Very slight	0.0	Very faint or none.	Very faintly. Veg.	3.25			.0002	.0008	.0006	.0002	.22	.0090	.0000	.0080	1.4	.0020
FROM TAP IN PUMPING STATION.																				
13550	1894 Dec 26	1894 Dec 27	None.	None.	0.00	None.	None.	3.30			.0000	.0004			.20	.0180	.0000	.0030	1.4	.0050
FROM TAP AT PUMPING STATION.																				

USE OF AIR IN PRESSURE GAGES.

BY

GEORGE E. WINSLOW, Superintendent, Waltham.

I haven't heard anybody tell here yet about the mistakes they have made. Now, these will happen once in a while, and they are sometimes of value to ourselves and to others. I have one little thing in mind, and have had for some time, which happened before I became connected with Water Works. A corporation, by whom I was employed, had a tank in the attic of their building, and as there was no way of knowing in the engine room where the pump was located, how much water there was in that tank, it would sometimes overflow and damage the rooms below. Instead of obtaining a pressure gage, which would cost perhaps $4 or $5, it occurred to me that I could make one for 50 or 75 cents which would do the work in good shape.

With the aid of some iron pipe and a glass tube I constructed an air chamber so arranged that the pressure due to the depth of water in the tank was shown by the height of the water in the glass tube. When first used this was a success, but in a very few hours the air was absorbed by the water, and the gage would not register correctly.

Not being acquainted with this propensity of water to absorb air when compressed it was some time before I discovered the cause of the difficulty.

At another time I established a float gage in the pumping station connected with the river by a pipe which for a short distance was raised slightly above the level of the water in the river. I had an idea that this would act as a siphon but I soon found that water would give out air as well as absorb it and that my plan was a failure.

New England Water Works Association Membership Roll.

June 1, 1895.

Note.—The secretary requests to be advised of existing errors or change of address from that which appears in the following list.

ACTIVE MEMBERS — RESIDENT AND NON-RESIDENT.

Abbott, Everett L.
218 Columbus avenue, Boston Mass.

Allen, Charles A.
Civil Engineer, 44 Front street, Rooms 109 and 110, Worcester, Mass.

Allen, Charles F.
Treasurer, Hyde Park, Mass.

Allis, Solon M.
Civil Engineer, Madison, N. J.

Andrews, Frank A.
Assistant Superintendent, Nashua, N. H.

Armstrong, S. G.
First Assistant Public Works Office, Pittsfield, Mass.

Babbidge, P. F.
Superintendent, Keene, N. H.

Babcock, Stephen E.
Chief Engineer, Little Falls, N. Y.

Bacot, R. C., Jr.
Superintendent Meter Department, P. O. Box 461, Port Chester, N. Y.

Bagnell, Richard W.
Superintendent, Plymouth, Mass.

Bailey, George I.
Superintendent, 61 State street, Albany, N. Y.

Baldwin, Charles H.
Box 2410, or 159 Franklin street, Boston, Mass.

Baldwin, Richard
Proprietor Water Works, Terryville, Conn.

Bancroft, Arthur G.
Civil Engineer, Box 506, Reading, Mass.

Bancroft, Lewis M.
Superintendent, Reading, Mass.

Barbour, Frank A.
Civil Engineer, P. O. Box 1235, Brockton, Mass.

Barns, Everett
Superintendent, Westerly, R. I.

Barrett, Albert P.
Water Registrar, Woburn, Mass.

Barrus, George H.
Consulting Steam Engineer, 95 Milk street, Boston, Mass.

Bartlett, Charles H.
Civil Engineer, 852 Elm street, Manchester, N. H.

Bassett, Carroll Ph.
Civil Engineer, Summit, N. J.

Batchelder, George E.
Registrar, Worcester, Mass.

Batcheller, Francis
Commissioner, North Brookfield, Mass.

Bates, Theodore C.
Chairman Water Commissioners, North Brookfield. Address, 29 Harvard street, Worcester, Mass.

Battles, James M.
120 Marginal, cor. Cottage street, East Boston, Mass.

Beals, Joseph E.
Superintendent, Middleboro, Mass.

Beasom, C. B.
Civil Engineer, 71 Wall street, New York city.

Benzenberg, G. H.
City Engineer, Milwaukee, Wis.

Berkey, John A.
Pres. Electric and Water Co., Little Falls, Minn.

Bickford, Nathan B.
61 Minot street, Neponset, Mass.

Billings, William R.
15 Harrison street, Taunton, Mass.

Birkinbine, Harry
Civil Engineer, Wayne, Delaware County, Penn.

Bishop, George H.
Civil Engineer, Middletown, Conn.

Bishop, Watson L.
Superintendent, Dartmouth, N. S.

Blossom, William L.
Civil Engineer, 355 Washington street, Brookline, Mass.

Boggs, Edward M.
Professor of Civil and Hydraulic Engineering, University of Arizona, Tucson, Arizona.

Bolling, Charles E.
Superintendent, Richmond, Va.

Bowers, George
City Engineer, Lowell, Mass.

Brackett, Dexter
Assistant Engineer, City Engineer's office, City Hall, Boston, Mass.

Bradley, R. H.
Receiver, Marshall and Burdick, Contracting Engineers, Watertown, South Dakota.

Brinsmade, Daniel S.
Engineer and Agent Ousatonic Water Co., Birmingham, Conn.

Broatch, J. C.
Superintendent, Middletown, Conn.

Brown, Arthur W. F.
Registrar, Fitchburg, Mass.

Brown, Edward H.
Superintendent and Treasurer Nevada County, N. G. R. R., Grass Valley, Cal.

Brown, J. Henry
3 Tremont street, Charlestown, Boston, Mass.

Brown, Milton A.
Superintendent, Perth Amboy, N. J.

Brownell, Ernest H.
174 Weybosset street, Providence, R. I.

Brush, Charles B.
Civil Engineer, 1 Newark street, Hoboken, N. J.

Bucknam, Geo. A. P.
Superintendent, Norwood, Mass.

Burleigh, John M.
Superintendent, South Berwick, Maine.

Burley, Harry B.
31 Milk street, Room 55, Boston, Mass.

Burnham, Albert S.
Superintendent, Revere, Mass.

Burnie, James
Superintendent, Biddeford, Me.

Burr, William H.
Professor of Civil Engineering, Columbia College, and Consulting Engineer, New York city.

Bush, Edward W.
City Engineer's Office, Waterbury, Conn.

Butler, J. Allen
Superintendent, Portland, Conn.

Cairns, R. A.
City Engineer, Waterbury, Conn.

Carroll, Fred. B.
8 Dexter street, Woonsocket, R. I.

Cavanagh, John T.
Water Commissioner, Quincy, Mass.

Chace, George F.
Superintendent, Taunton, Mass.

Chadbourne, E. J.
Superintendent, Wakefield, Mass.

Chaffee, Fred. I.
Superintendent, East Providence Center, R. I.

Chandler, Charles E.
City Engineer, 161 Main street, Norwich, Conn.

Chandler, Charles F.
Professor of Chemistry, School of Mines, Columbia College, New York city.

Chase, John C.
Superintendent, Wilmington, N. C.

Childs, Wm. H.
226 Clinton avenue, Brooklyn, N. Y.

Clark, D. W.
President Water Company, Portland, Me.

Clark, Ezra
President and Superintendent, Hartford, Conn.

Clark, Frederick W.
Clerk, Chestnut Hill Reservoir, Boston, W. W., Brighton, Mass.

Clark, Harry W.
State Experiment Station, Lawrence, Mass.

Clarke, E. W.
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Cleaveland, W. F.
Brockton, Mass.

Cochran, Robert L.
Superintendent, Nahant, Mass.

Codd, William F.
Superintendent, Nantucket, Mass.

Coffin, Freeman C.
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Coggeshall, R. C. P.
Superintendent, New Bedford, Mass.

Collins, Lewis P.
Water Commissioner, Lawrence, Mass.

Conant, H. W.
Superintendent, Gardner, Mass.

Conant, Whitney
Secretary Water Co., Long Branch, N. J.

Congdon, John L.
East Greenwich, R. I.

Connell, Michael A.
Superintendent, St. Hyacinthe, P. Q.

Cook, Byron I.
Superintendent, Woonsocket, R. I.

Cook, Henry A.
Superintendent, Salem, Mass.

Crandall, F. H.
Superintendent and Treasurer, Burlington, Vt.

Crandall, George K.
Civil Engineer, New London, Conn.

Crilly, P. F.
Superintendent, Woburn, Mass.

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Daboll, L. E.
Superintendent, New London, Conn.

Darling, Edwin
Pawtucket, R. I.

Davis, F. A. W.
Vice-President and Treasurer Water Co., Indianapolis, Ind.

Davis, William E.
Superintendent, Sherburne, N. Y.

Davison, George S.
Civil Engineer, Pittsburgh, Penn.

Dean, Francis W.
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Dean, Seth
Civil Engineer, Glenwood, Iowa.

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Secretary and Manager, Des Moines, Iowa.

Dennett, Nathaniel
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Devlin, George A.
Asst. Engineer Boston Water Works, Marlborough, Mass.

Diven, J. M.
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Doherty, Cornelius F.
Registrar, Room 15, City Hall, Boston, Mass.

Dolan, Edward
Superintendent, Troy, N. Y.

Doran, Hugh F.
Superintendent, Port Huron, Mich.

Dotten, William T.
Superintendent, Winchester, Mass.

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Civil Engineer, 164 William street, New Bedford, Mass.

Drake, B. Frank
Water Commissioner, Lakeport, N. H.

Drake, Charles E.
Civil Engineer, New Bedford, Mass.

Drown, Thomas M.
Professor of Chemistry, Mass. Inst. of Technology, Boston, Mass.

Dunbar, E. L.
Superintendent, Bay City, Mich.

Dyer, Eben R.
Superintendent Distribution, Portland, Me.

Eardley, B. A.
Superintendent Pacific Improvement Co. Water Works, Pacific Grove, Monterey Co., Cal.

Eaton, Horace L.
City Engineer, Somerville, Mass.

Eddy, Harrison P.
Supt. Sewer Dept., City Hall, Worcester, Mass.

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Civil Engineer, 158 Sherman street, Springfield, Mass.

Ellis, John W.
Woonsocket, R. I.

Ellison, W. P.
President Water Board, Newton, Mass.

Ervin, John
Secretary and Treasurer Middleton Water Supply Co., Bridgetown, N. S.

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City Engineer, Marlboro, Mass.

Felton, Charles R.
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Fifield, John W. D.
Water Commissioner, North Brookfield, Mass.

Fiske, Wilbur D.
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FitzGerald, Desmond
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Forbes, F. F.
Superintendent, Brookline, Mass.

Forbes, Murray
Manager Westmoreland Water Co., Greensburgh, Penn.

Forbes, Z. R.
Water Registrar, Brookline, Mass.

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Fuller, Geo. W.
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Gamwell, J. H.
Treasurer Water Company, Palmer, Mass.

Gardner, L. H.
Superintendent Water Works Company, New Orleans, La.

Gerhard, William Paul
Civil Engineer, Consulting Engineer for Sanitary Works, 36 Union Square, East, New York city.

Gerrish, William B.
Superintendent, Oberlin, Ohio.

Gerry, L. L.
Civil Engineer, Room No. 1, Chase's Block, Stoneham, Mass.

Gilbert, Julius C.
Superintendent, Whitman, Mass.

Gleason, T. C.
Superintendent, Ware, Mass.

Glover, Albert S.
36 Bromfield street, Room 8, Boston, Mass.

Goodier, Andrew B.
Treasurer and Superintendent, Southbridge, Mass.

Goldthwait, W. J.
Marblehead, Mass.

Goodnough, X. H.
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Gow, Frederick W.
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Greetham, H. W.
Local Manager, Water and Sewerage Co., Orlando, Fla.

Griffith, William E.
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Groce, William R.
Superintendent, Rockland, Mass.

Hale, Richard A.
Principal Assistant Engineer, Essex Company, Lawrence, Mass.

Hall, Frank E.
Superintendent, Box 124, Quincy, Mass.

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Civil Engineer, 29 Pemberton square, Boston, Mass.

Hammond, J. C., Jr.
Secretary and Treasurer, Rockville, Conn.

Hancock, Joseph C.
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Haring, James S.
Civil Engineer, Lock Box 74, Nyack, Rockland Co., N. Y.

Harrington, Geo. W.
Wakefield, Mass.

Harrington, John L.
Superintendent, Cambridge, Mass.

Harris, D. A.
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Harris, John
21 Cherry street, Waltham, Mass.

Hart, Edward W.
General Manager Water Works, Council Bluffs, Iowa.

Hartwell, David A.
City Engineer, Fitchburg, Mass.

Haskell, John C.
Superintendent, Lynn, Mass.

Hastings, L. M.
City Engineer, Cambridge, Mass.

Hastings, V. C.
Superintendent, Concord, N. H.

Hathaway, A. R.
Registrar, Springfield, Mass.

Hathaway, James H.
Registrar, New Bedford, Mass.

Hawes, Louis
Civil Engineer, 75 State street, Boston, Mass.

Hawes, William B.
Water Commissioner, Fall River, Mass.

Hawes, William M.
Fall River, Mass.

Hawks, William E.
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Hayes, Ansel G.
Assistant Superintendent, Box 323, Middleboro, Mass.

Hazard, T. G., Jr.
Civil Engineer, Narragansett Pier, R. I.

Hazen, Allen
Civil Engineer, 85 Water street, Boston, Mass.

Heald, Simpson C.
Civil Engineer, 48 Congress street, Boston, Mass.

Heermans, Harry C.
Superintendent, Corning, N. Y.

Henderson, Wilson
Superintendent, Peterborough, Ontario, Canada.

Hering, Rudolph
Civil and Sanitary Engineer, 277 Pearl street, New York city.

Herschel, Clemens
Hydraulic Engineer, 2 Wall street, Room 66, New York city.

Hicks, R. S.
Secretary, Stafford Springs, Conn. Box 543.

Higgins, James H.
Supt. Meter Department, City Hall, Providence, R. I.

Hill, William R.
Chief Engineer, Syracuse, N. Y.

Hodgson, John S.
Wellington, Mass.

Holden, Horace G.
Superintendent, Nashua, N. H.

Holman, M. L.
Water Commissioner, 3744 Finney avenue, St. Louis, Mo.

Hunking, Arthur W.
Care Mass. Mills, Rome, Ga.

Hunter, Henry G.
Civil Engineer, John Hancock Building, Boston, Mass.

Huntington, James A.
Registrar, Haverhill, Mass.

Hyde, Horatio N.
Superintendent, Newtonville, Mass.

Inman, A. W.
Superintendent Water Supply Co., Massillon, Ohio.

Jackson, Daniel D.
Water Analyst Boston Water Works, Newtonville, Mass.

Jackson, William
City Engineer, City Hall, Boston, Mass.

Johnson, William S.
Sanitary Engineer, Department of Health, 40 Clinton street, Brooklyn, N. Y.

Jones, A. J.
New Brunswick, N. J.

Jones, James A.
Registrar, Stoneham, Mass.

Jones, R. A.
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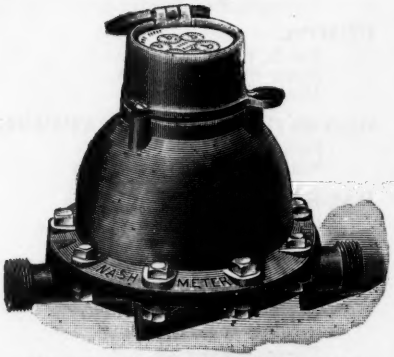

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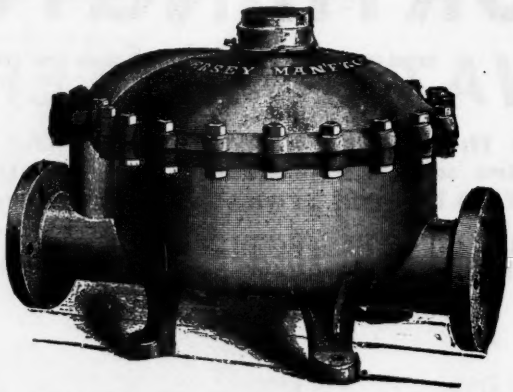

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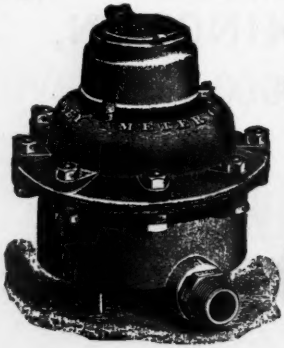

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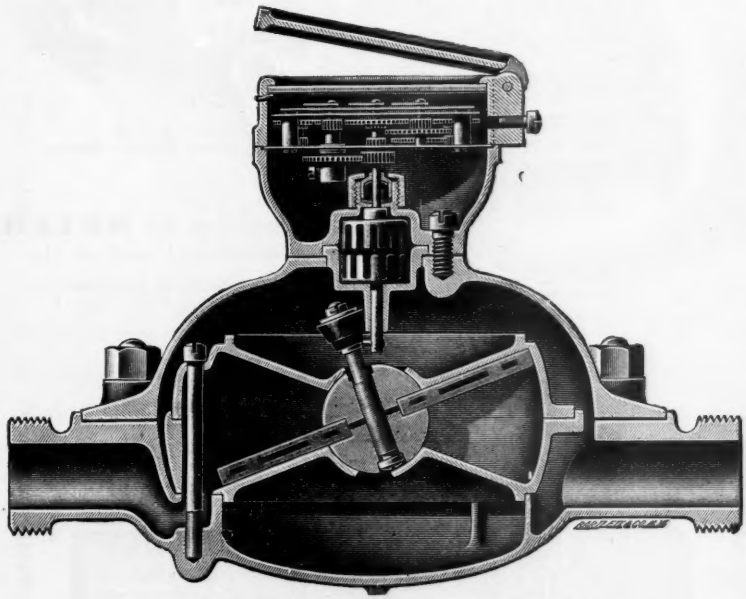

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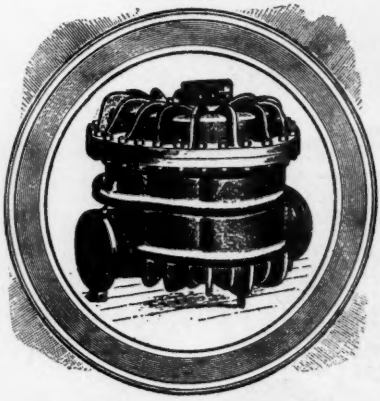

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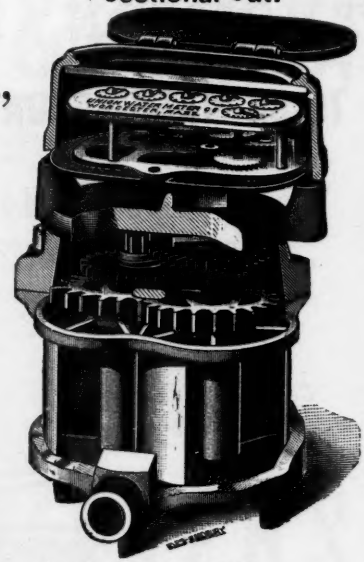

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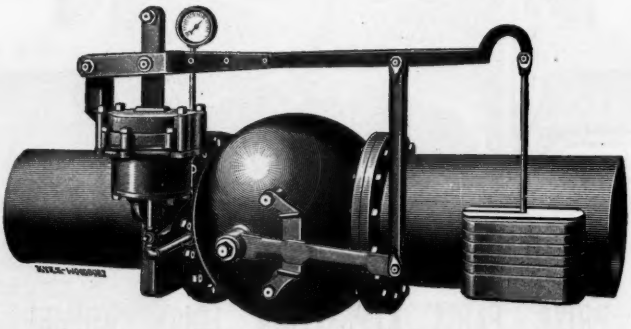

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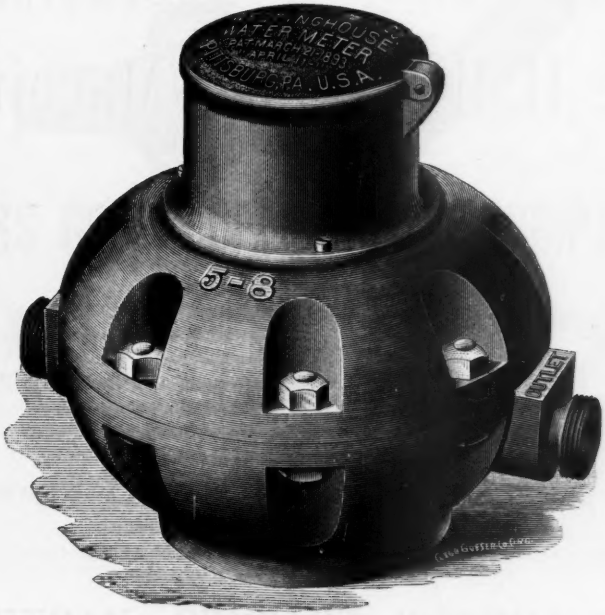

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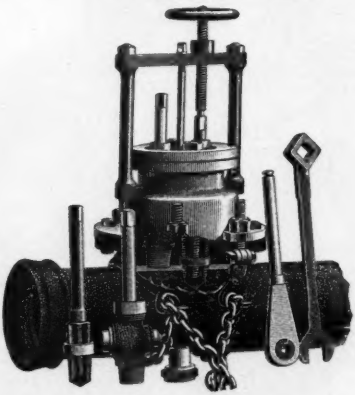

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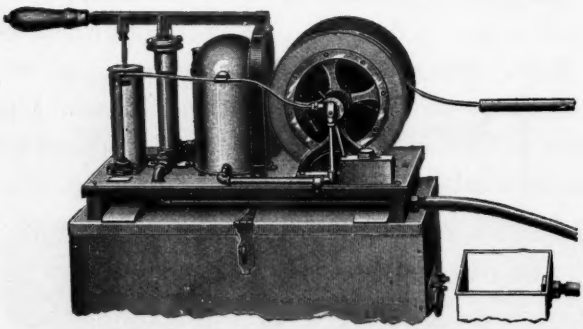

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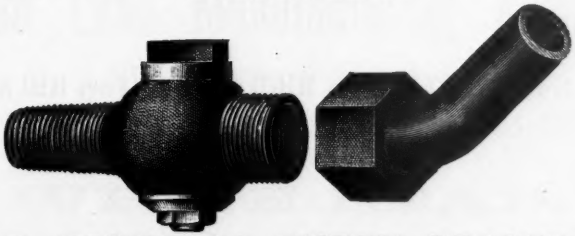

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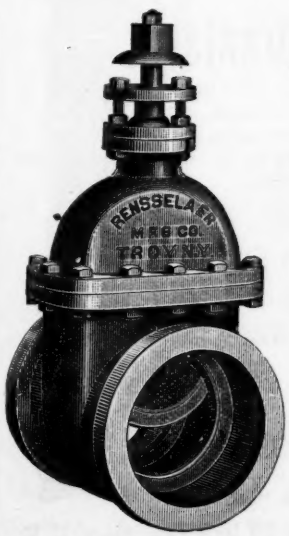

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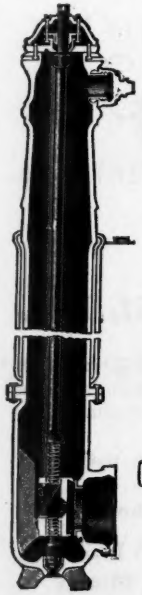

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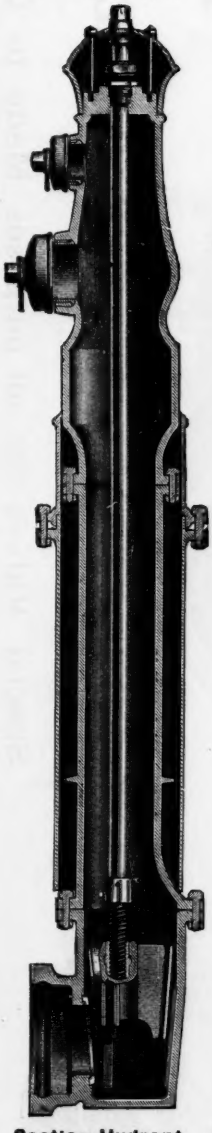

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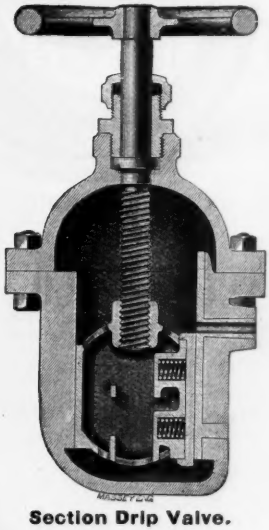

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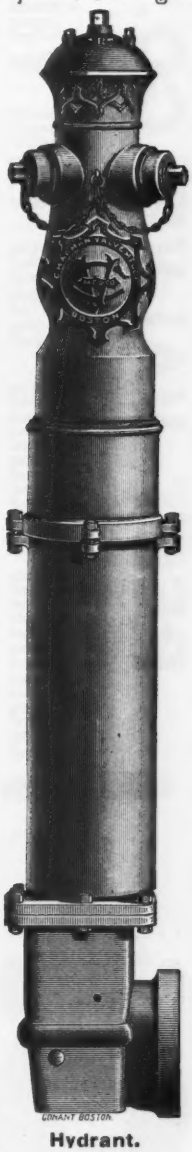

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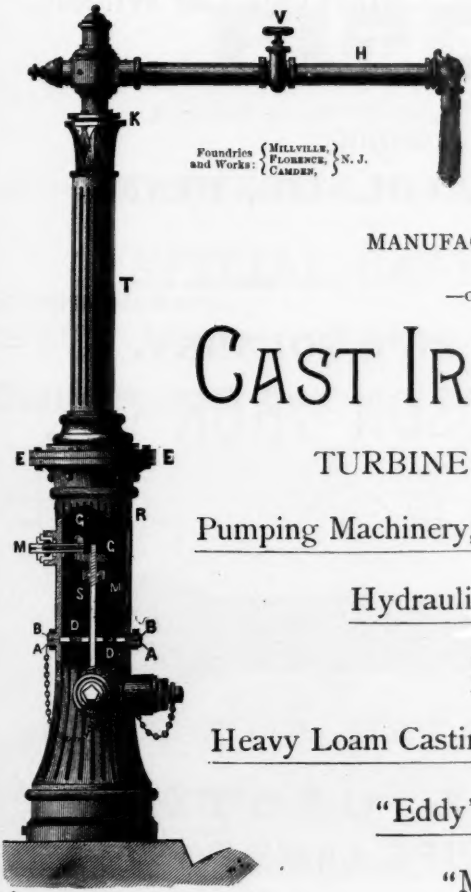

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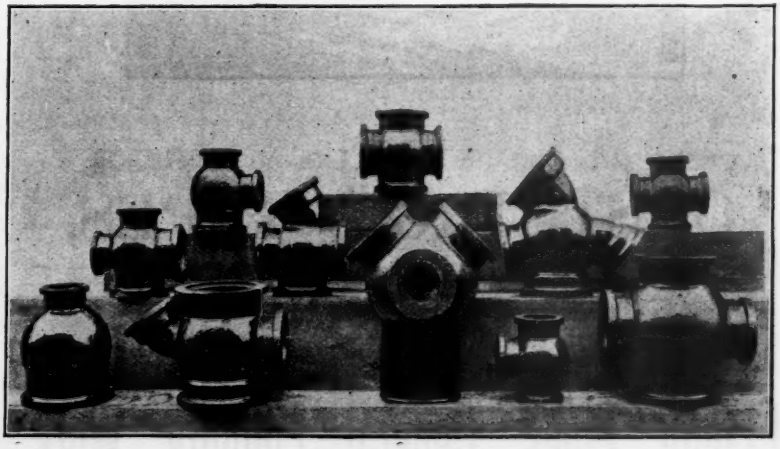

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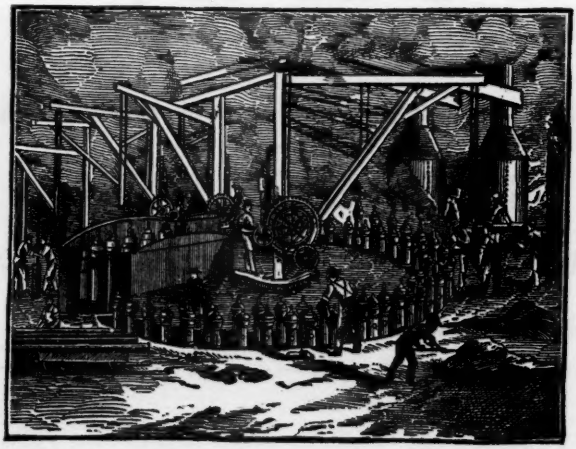

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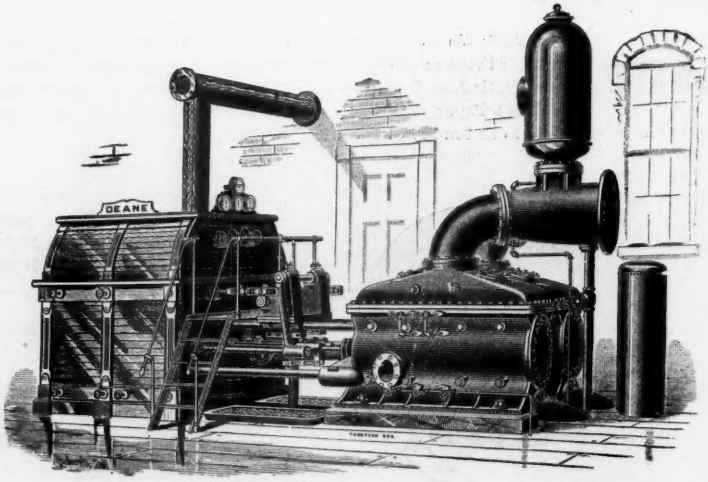

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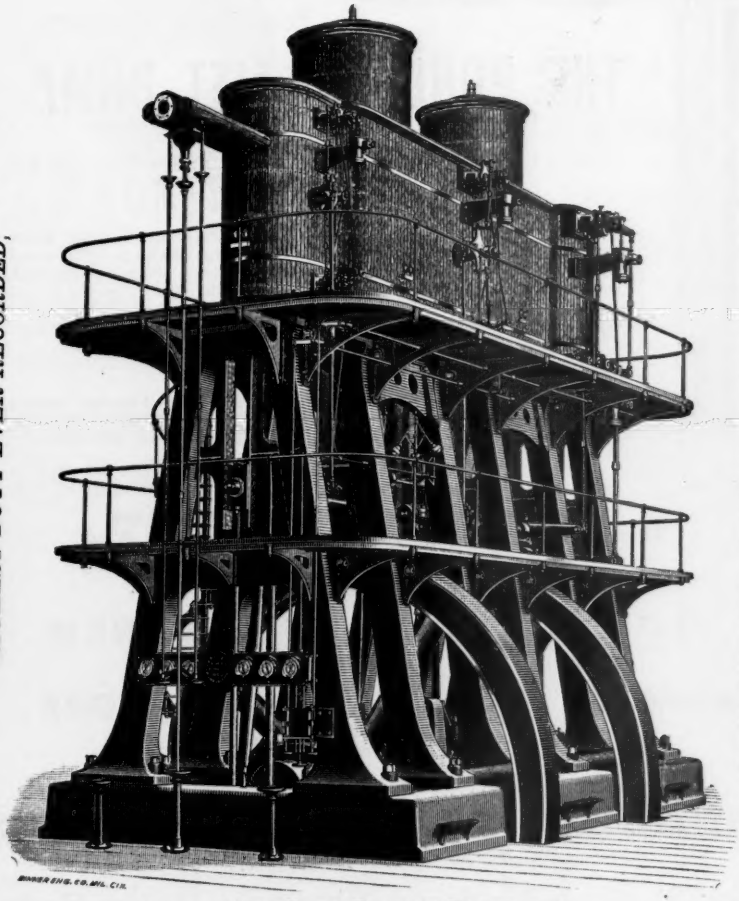

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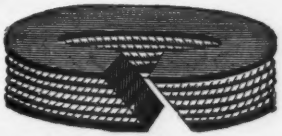

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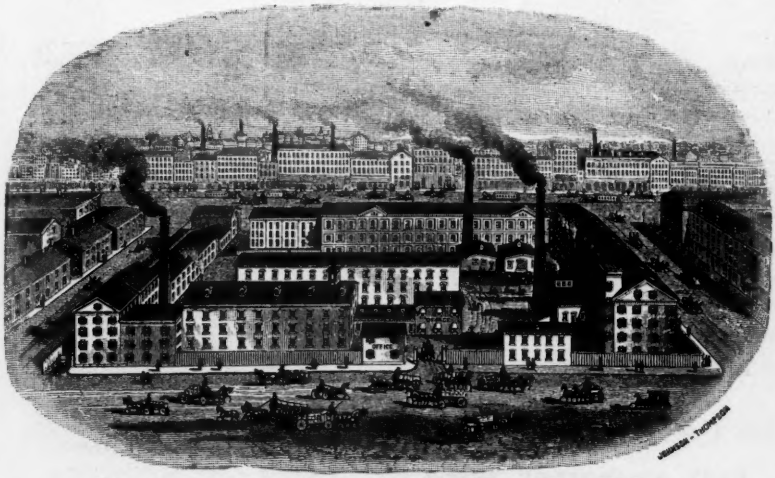

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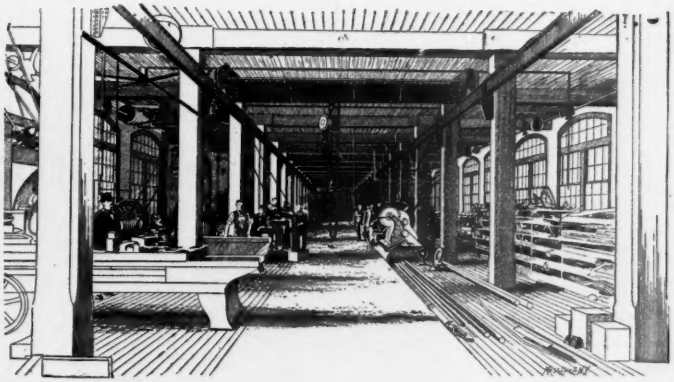

The above illustration is taken direct from a photograph and shows the construction of a Traveling Crane placed by us in the Machine Shop of the National Meter Co., at Brooklyn, N. Y. The building is the usual construction of brick walls with wooden posts supporting wooden floors. The crane girders are attached to wooden posts, and the Crane has a travel the full length of the building between the posts. The plan commends itself where parties desire to control a limited floor space in a building already built.

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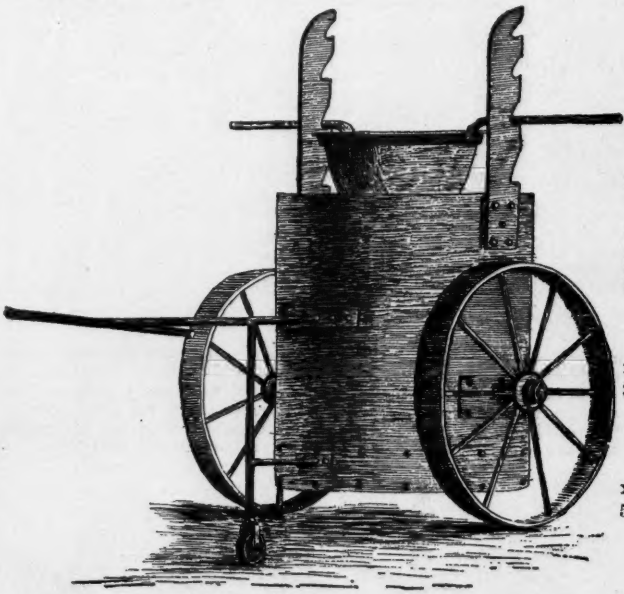

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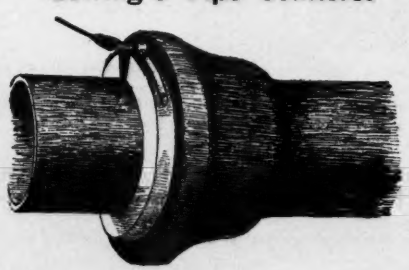

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